CONGRESS PROGRAMME

ESMAC
21st Annual Meeting of ESMAC Stockholm
13-15 september 2012

21st Annual Meeting of ESMAC

September 13-15, 2012
Stockholm, Sweden
www.esmac2012.com

Welcome to the 21st Annual Meeting of ESMAC

13–15 september 2012

Stockholm, Sweden

ESMAC

21st Annual Meeting of ESMAC Stockholm

13-15 september 2012

DEAR MEMBERS, COLLEGUES AND FRIENDS

A WARM WELCOME to the 21st Annual Meeting of the European Society of Movement Analysis for Adults and Children (ESMAC). The congress is suitable for those interested in the clinical and technical aspects of movement analysis. This multidisciplinary congress provides a forum for researchers and clinicians involved in clinical gait analysis. Presentations will cover State of the Art developments in movement analysis for adults and children, new methodologies and developing expertise in clinical decision making.
Our pre-congress gait analysis basic course (September 10-12) and a two day advanced course (September 11-12) are aimed at beginners and experienced professionals. The courses will be held at Karolinska University Hospital and the congress will be held at the Stockholm Waterfront Congress Centre, which is located ideally in the heart of the city. This new congress center will accommodate everything from the welcome reception, coffee breaks, lunches, posters and exhibitions in the same area. Stockholm enjoys the benefits of a world-class transport infrastructure, and people come here for the food, the design and the music. It also offers a unique range of galleries and museums, and every year the eyes of the world are on the city when the Nobel Prizes are awarded. Stockholm combines the charm of a small, old town with the cultural and commercial attractions of a big, modern city and is ranked as one of the most popular congress destinations in the world. We are certain that this will be a memorable and enjoyable meeting.
Welcome to ESMAC 2012 in Stockholm.

PhD. PT, Eva W Broström
Congress President

PhD. ir. Jaap Harlaar
President ESMAC

Supported by

Karolinska Institutet

KAROLINSKA
Universitetssjukhuset

Platinum sponsor

QUALISYS
Motion Capture Systems

Silver sponsor

teamolmed

WELCOME WORDS BY FILIPPA REINFELDT

Dear Participants,
A warm welcome to Stockholm and Sweden!

You have chosen an interesting and exciting time to visit us since Sweden, and Stockholm in particular, is expanding its efforts in medical research and technology. Stockholm has been the birthplace of many well known pharmaceuticals and medical equipment and now our goal is set even higher.

Stockholm county council is currently underway of building a new top modern hospital. This new hospital, Karolinska Universtetssjukhuset, will be the center of medical research and development in Sweden. As Stockholm County Health Commissioner it is of great importance to me that all citizens have equal right and equal opportunity to seek and receive medical treatment. But also to pave the way of future medical treatment and assist the research community in developing even smarter and more patient safe equipment and more effective medicine.

I sincerely hope that you will enjoy an eventful Annual Meeting and together with lively discussions grow even stronger as an organization. Hopefully you will have the time to see some of the beautiful and interesting sights of Stockholm before you leave.

Best of luck to you and the conference!

Filippa Reinfeldt
Healthcare Commissioner of Stockholm County Council

CONGRESS VENUE

Stockholm Waterfront Congress Centre
Nils Ericsons Plan 4
111 64 Stockholm
Sweden
Tel +46 (0)8 50 50 6000
www.stockholmwaterfront.com

REGISTRATION

The registration desk, located at Stockholm Waterfront Congress Centre will be open at the following hours:
Wednesday 12 September 15.00 – 19.00
Thursday 13 September 08.00 – 18.00
Friday 14 September 08.00 – 18.00
Saturday 15 September 08.00 – 13.00

Telephone during opening hours: +46 (0)8 505 067 80

Included in registration

The registration fee for the meeting includes the following:
- admission to all meeting sessions, poster sessions and exhibition
- program and abstract books
- access to the welcome reception
- coffee, tea and lunch during the meeting breaks

INSTRUCTIONS FOR ORAL PRESENTERS

Preview Centre

Presentations will be performed using PowerPoint file format on Windows PC (MS Office 2010). Only digital material will be allowed for podium presentations. In the interests of time-keeping, we recommend no more than one slide per minute.

Presentations should be provided on a USB-removable drive to the Preview Centre. Due to time and technical restraints during the sessions, personal laptops may not be used in the session rooms.

You are kindly asked to come to the Preview Centre and check-in your presentation (on your USB-removable drive), no later than 3 hours before the start of the session during which you will give the presentation. If your session starts early in the morning, please check-in your presentation in the afternoon of the preceding day.

Opening Hours Preview Centre

Wednesday 12 September 18.00 – 19.00
Thursday 13 September 08.00 – 18.00
Friday 14 September 08.00 – 18.00
Saturday 15 September 08.00 – 09.00

Presentations

Each presenter must make him/herself known to the chairpersons, who will moderate your session, shortly before the start of the session (if the session is preceded by a keynote, before that moment). Note that the speaking time is 8 minutes + 2 minutes for questions and discussion.

INSTRUCTIONS FOR POSTER PRESENTERS

Posters should be up between Thursday 13th 09.00 and Friday 14th 14.30 in the exhibition hall. You can put up your poster Wednesday September 12th between 18.00-19.00 or Thursday between 08.00-09.00 in the exhibition hall. Please check your poster number in the program (available onsite) and mount your poster at your assigned position. Material for temporarily attaching posters to boards will be provided onsite. Posters should be taken down no later than Friday 14th at 19.00.

The interactive poster session will be held on Thursday, September 13th from 13.00–14.30 (odd numbers on blue poster note) and Friday September 14th 13.00–14.00 (even numbers on yellow poster notes). No other session or lecture is held during the poster sessions. Presenting the poster means that the author is available for information, questions and discussions for the whole session.

CONGRESS INFORMATION

Certificate of Attendance

Your Certificate of Attendance will be included in your conference material available at the registration desk.

Conference Language

The official language of the meeting is English. No simultaneous interpretation will be provided.

First Aid

If needed, please contact the staff at the registration desk or dial 112.

Cloakroom

Outerwear and luggage can be stored in the cloakroom in the main entrance hall.

Important contacts

Organizer & Scientific Secretariat
Astrid Lindgren Children's Hospital
at Karolinska University Hospital
Karolinska Institutet
Motion Analysis Laboratory Q2:07
117 76 Stockholm, Sweden
Phone: +46 (0)8 517 77 636
Fax: +46 (0)8 517 77 349
Email: info@esmac2012.com

Official PCO, Sponsorship &
Exhibition Management
Arrangera Nöje & Konferens AB
Tegnérgatan 45,
111 61 Stockholm, Sweden
Project Manager: Maria Ekdahl
Telephone: +46 (0)8 545 833 40
Fax: +46 (0)8 545 83 349
Email: esmac2012@arrangera.com

Insurance and liability

The organisers cannot be held responsible for any personal injury, loss, damage or accident to private property, or for additional expenses incurred as a result of delays or changes in air, rail, road or other services, strikes, illness, weather and other causes. All participants are encouraged to make their own arrangements for health and travel insurance.

Internet Access

Wireless LAN (W-LAN) will be available for free for all participants and exhibitors.

UserID: esmac
Password: esmac

Name Badges

All participants are requested to wear their name badge during the congress and social programme. The access to the Scientific Programme and social events is restricted to those who have registered and wear their badges.

The following badges colours are used at the conference:

BASIC GAIT COURSE
ADVANCED GAIT COURSE
CONGRESS
STAFF
EXHIBITORS
PRESS

Messages

Messages to delegates should be handed in at the registration desk. Notification of message receipt will be displayed on the message board next to registration desk. Please check the board daily and pick up your messages – they may be urgent.

Venue

Stockholm Waterfront Congress Centre is located in the city center and close to the Central Station. It is only 20 min by train from Arlanda airport.

Address

Stockholm Waterfront Congress Centre
Nils Ericsons Plan 4
111 64 Stockholm, Sweden

To the airport

Airport buses are cheaper, but Arlanda Express trains are climate smart and much faster. It's also easy to get fixed-price taxis to and from Stockholm's airports or to rent cars.

PRACTICAL INFORMATION

Currency

The official currency in Sweden is Swedish Crowns (SEK). As an indication only: the recent historical exchange rate was around 100 SEK = 12 Euro.

Public transportation

You can travel with public transportations throughout the Greater County of Stockholm. The area covers a distance of several kilometres outside the actual city centre and includes all services on the Metro, commuter rail, light railways such as the Roslagsbanan, Saltsjöbanan, and the Lidingöbanan trains, and hundreds of bus lines. Tickets are sold via their agents, at the SL Center and at commuter train stations. Some tickets can also be bought at the Metro barriers. There are also ticket machines at most Metro and commuter railway stations, as well as in a number of other locations. You can even buy a zone ticket which is sent as a text message to your mobile phone. It is always cheaper to buy prepaid tickets and the longer the period of validity of the ticket, the cheaper it will be per day.
For short visits there are travelcards for 1, 3 or 7 days.

Weather

Average high temperatures in Stockholm in September are around 15° C by day and nights are cooler. For detailed weather information, please visit www.SMHI.se

Electricity

The main voltage in Sweden is 220V.

Time

Stockholm is in the Central European Time Zone, two hours ahead of Greenwich Mean Time (GMT), still during daylight saving time.

Useful Telephone Numbers

Emergency: 112
Taxi: +46 (0)8 15 00 00 (Taxi Stockholm) or +46 (0)8 30 00 00 (Taxi Kurir)
Stockholm Tourist Center: +46 (0)8 508 28 508

Banks, Currency and Credit Cards

Most Swedish banks will change traveller's cheques as well as cash. Banking hours in general are Monday-Friday 08.00-15.00, although some banks are open later. ATMs are located outside most banks, and cash can be withdrawn there 24/7. National and foreign Maestro cards (debit cards) as well as Mastercard, AMEX, Visa and Diners are accepted. Forex operates a large number of foreign exchange bureaus in central location. Credit cards are also accepted by most hotels, restaurants, cafés, shops, taxis and gas stations.

Shopping

Most shops are at least open from Monday to Friday 10.00-18.00 and Saturday 10.00-15.00. However, many shops and department stores in the central parts of the city are open longer hours as well as on Sundays.

Tipping

Service is usually included in the prices in bars and restaurants. For exceptional service, tip an extra 5-10%.

SOCIAL PROGRAMME

Congress Welcome Reception on Wednesday, September 12, 2012 at 19.00–21.00

Reception for registered participants, accompanying persons and exhibitors take place at Stockholm Waterfront Congress Centre. Tickets are included in the regular fee for participants. Extra tickets for exhibitors and accompanying persons can be purchased at the registration desk, SEK 150 per person.

Congress Dinner on Friday, September 14, 2012 at 19.30

The dinner will take place at Junibacken in a house of fantasy and play. You will experience the Story Train, which is a journey through the fabulous stories of Astrid Lindgren. A three course menu as well as an appetizer and drinks will be offered. Junibacken is situated on Djurgården in Stockholm, just behind Nordiska Museet in Galärparken, next door to the Vasa Museum. Tickets can be purchased at the registration desk, SEK 650. At 18.30, all attending the gala dinner at Junibacken will travel together. Meet at the main entrance of the Waterfront Congress Center.

GENERAL INFORMATION ABOUT STOCKHOLM

Stockholm, one of the most beautiful capitals in the world, is built on 14 islands connected by 57 bridges. The beautiful buildings, the greenery, the fresh air and the proximity to the water are distinctive traits of this city. The Royal National City Park, (the first National City Park in the world), is a green space that breathes for the city, and a constant presence in the heart of the city.

With its 750 year history and rich cultural life, Stockholm offers a wide selection of world-class museums and attractions. Most of the city's attractions can be reached on foot, and there's a good chance of experiencing a lot of things in a short time. Experience big-city life, the history of civilization and natural scenery, all in the course of the same day.

Visit Stockholm City Hall. Climb the City Hall tower for a fantastic view of Stockholm. Don't miss Gamla Stan, Stockholm's oldest attraction and one of the best preserved medieval city centers in the world. Walk through small winding streets lined with stores full of handicrafts, antiques, art galleries and cafés. The Royal Palace and Stockholm Cathedral are also located in Gamla Stan.

The green island of Djurgården is home to some of the city's most popular attractions. Visit the world-famous warship the Vasa, the world's oldest open-air museum Skansen, or Astrid Lindgren's Junibacken. And don't miss the chance to see Stockholm from the water. Naturally a city built on fourteen islands offers marvelous views over the water. There are many different sightseeing tours to choose from. And if fourteen islands aren't enough, Stockholm offers a wonderful archipelago with 30,000 islands, islet rocks and skerries.

VISIT STOCKHOLM

The Vasa Museum

– From Wreck to state of the art!

Address: Galärvarvsvägen 14, Djurgården, Stockholm
Open: 08.30-18.00 daily
www.vasamuseet.se/en

Discover Stockholm by boat!

Welcome to our fantastic capital where city life meets nature and a lot of water. Stockholm offers a great variety of things to do and this site will help you find activities in Stockholm and the surrounding archipelago.
www.stromma.se/en/stockholm

The Royal Palace of Stockholm

Open: 15 May – 16 September: Daily 10.00–17.00
17 September – 14 May: Tues–Sun 12.00–16.00

Welcome to one of Europe's largest and most dynamic palaces!

The Royal Palace of Stockholm is His Majesty The King's official residence and is also the setting for most of the monarchy's official receptions. The palace is a daily place of work for The King and Queen as well as for the various departments that make up the Royal Court. This combination of royal residence, workplace and culture-historical monument open year round to visitors makes the Royal Palace of Stockholm unique amongst Europe's royal residences.

The Old Town

Stockholm was founded in the 13th century. The Old Town is the origin of Stockholm City and the Old Town constituted the main part of the city for several hundred years. The old town was for a long time the city in contrast to the more rural surroundings, Norrmalm, Södermalm and Östermalm (which are now also part of the city and heavily populated). There are now less than 3000 people living in the Old Town. Most of the buildings are from the 17th and 18th century. The Old Town has a large number of restaurants, tourist shops, art shops and museums.
www.gamla-stan-stockholm.se/

Visit "Artipelag"

Artipelag is a new and unique international venue where art exhibits, inspiring cultural activities, architecture, music, Swedish design and great dining live side by side with the beautiful archipelago environment. Travel by sea from Stockholm or Gustavsberg! Several ferry companies offer trips to Artipelag. The boat journey takes just over an hour and docks directly at Artipelag's pier.
www.artipelag.se/en/visit-artipelag

More activities, more attractions, more restaurants:
www.visitstockholm.com/en/

Notes

Thursday Sept 13

	A2, Main Lecture Hall, Level 6	C4, Lecture Room, Level 2
09.00-09.10	Opening and Welcome	
09.10-10.00	Session 1 Children's Orthopeadics	
10.00-10.30	Coffee in the Exhibition Hall	
10.30-11.15	Baumann Lecture Carlo Frigo	
11.15-12.00	Session 2a Imaging Methods	Session 2b Knee Osteoarthritis
12.00-13.00	Lunch and Coffee in the Exhibition Hall	
13.00-14.30	Poster Session in the Exhibition Hall & Balcony Neurology, Children, Orthotics	
14.30-15.00	Keynote Lecture I Tim Theologis	
15.00-15.30	Coffee in the Exhibition Hall	
15.30-17.00	Session 3a Cerebral Palsy Descriptive	Session 3b Technical and Simulation
17.15-19.00		ESMAC Annual General Meeting
19.00	User Group Meetings	

Trigno™ Solutions
...take your research to new heights.

Physiological monitoring
- Full-bandwidth sEMG sensors
- Accurate EKG sensors
- 3DOF inertial sensors
- Global positioning sensors
- Force sensors
- Angle sensors

8 hours of mobile data logging
Trigno™ Mobile supports 8 hours of continuous logging for capturing long term physiological trends.

40 meters indoor range
Trigno™ sensors are truly wire-free, allowing completely unrestricted subject motion while still maintaining optimal signal quality and full-bandwith sampling.

Trigno™ Mobile

Trade In Discount 40%

Trade in your old equipment towards Trigno™ Mobile or Trigno™ Lab.

Trigno™ Lab

www.delsys.com
(617) 236-0599 | delsys@delsys.com

For quotes, demos, or techincal support, please contact:
Steven Lindley B.Sc., M.Sc., Product Specialist
slindley@delsys.com | Skype: steven-lindley

THURSDAY, SEPTEMBER 13, 2012

09.00-09.10	WELCOME AND INTRODUCTION (A2)
09.10 - 10.00	SESSION 1 (A2) Children's Orthopeadics Chairmen: Stephanie Böhm, Andreas Kranzl
O01 Stief, Felix	Effect of intensive conservative therapy on gait performance in patients with Legg-Carvé-Perth-Disease
O02 Westhoff, Bettina	Change of Gait pattern after Pelvic Osteotomy in children with Legg-Calve-Perthes Disease
O03 Boehm, Harald	Predictors of compensatory and adaptive trunk movements during gait in children with Arthrogryposis Multiplex Congenita
O04 Engström, Pähr	Botulinum toxin A does not improve cast treatment for idiopathic toe-walking- a prospective randomized trial
O05 Kranzl, Andreas	Outcome of 23h Bracing for Tip-toe-walking Children with Cerebral Palsy

O01

EFFECT OF INTENSIVE CONSERVATIVE THERAPY ON GAIT PERFORMANCE IN PATIENTS WITH LEGG-CALVÉ-PERTHES DISEASE

Felix Stief[1], Moamer Brkic[2], Carsten Ebert[3], Lutz Vogt[3] and Andrea Meurer[2]

[1]Orthopaedic University Hospital Friedrichsheim gGmbH, Movement Analysis Lab, Frankfurt/Main, Germany
[2]Orthopaedic University Hospital Friedrichsheim gGmbH, Frankfurt/Main, Germany
[3]Goethe-University Frankfurt, Department of Sports Medicine, Frankfurt/Main, Germany

INTRODUCTION

The hip joint may develop early osteoarthritis in patients with Perthes disease [1]. Physical examination often shows a limitation in range of motion (ROM) for hip extension, abduction and internal rotation as well as an abductor weakness [2]. Conservative therapeutic training is an alternative to surgical interventions that can be used to improve altered biomechanics of the hip. While mechanisms of gait compensation in these patients have been well described [3], there is a lack of research on the effects of therapeutic training on gait performance. The purpose of the present study was to evaluate whether physiotherapy treatment could improve gait parameters in patients with Perthes disease.

PATIENTS/MATERIALS and METHODS

18 patients with unilateral Perthes disease and a mean age of 6.2 (±1.9) years participated in this prospective study. Gait analysis was performed immediately before and 12 weeks after intensive therapeutic training. Kinematic data were collected using an eight-camera Vicon system. One force plate (AMTI) was used to calculate mechanical power. The Helen Hayes marker set [4] was applied to determine joint centers. All subjects walked barefoot at a self-selected speed along a 15 m walkway. Differences were tested for significance using a paired *t*-test (significance level was set at $P < 0.05$). The absolute symmetry index (ASI) was determined on the basis of the symmetry index of Robinson et al. [5].

RESULTS

The thorax obliquity ROM was significantly decreased and hip power generation was significantly increased for the affected side during stance phase after therapeutic training. Moreover, the ASI showed a tendency towards an increasing symmetry between the affected and unaffected side for spatio-temporal parameters. In the clinical evaluation, the passive hip flexion increased significantly. However, the significantly decreased hip extension/flexion ROM of the affected side compared to the unaffected side did not changed after therapeutic training during walking.

DISCUSSION & CONCLUSIONS

These results suggest that therapeutic training can improve gait symmetry. In addition, as a result of the reduced Duchenne gait pattern, the mechanical energy generation by the hip extensors was increased. However, the decreased hip ROM in the sagittal plane did not changed during walking after a therapeutic training period of 12 weeks. In order to avoid long-term gait impairment, sagittal hip flexibility should be taken into account and also observed during the physiotherapy treatment period. Therefore, gait analysis can be used to objectively evaluate the functionality of the involved joint, to indicate the discrepancy between passive ROM and dynamic situations as well as for potentially therapeutic treatment modification.

REFERENCES

[1] Cooperman et al. (1986) Clin Orthop, 203:289-300. [2] Schulitz et al. (1998) Morbus Perthes, Springer, Berlin/Heidelberg/New York. [3] Westhoff et al. (2006) Gait Posture, 24:196-202. [4] Kadaba et al. (1990) J Orthop Res, 8:383-92. [5] Robinson et al. (1987) J Manipulative Physiol Ther, 10:172-6.

O02

CHANGE OF GAIT PATTERN AFTER PELVIC OSTEOTOMY IN CHILDREN WITH LEGG-CALVE-PERTHES DISEASE

Bettina Westhoff[1], Dietmar Rosenthal[1], Nina Palmen[1], Ruediger Krauspe[1] and Christoph Zilkens[1]

[1]Heinrich-Heine-University, Department of Orthopaedics, Duesseldorf, Germany

INTRODUCTION

Gait deviations were described previously in the floride as well as in the final stage in LCPD [1-3]. This study aimed to analyze whether the gait pattern normalizes after containment improving surgery.

PATIENTS/MATERIALS and METHODS

17 children with the diagnosis of LCPD (16 male, 1 female), who were treated by pelvic (Salter or Triple) and femoral osteotomy due to loss of containment, could be included. Inclusion criteria were 1. unilateral hip involvement, 2. follow-up of at least 2 yrs., 3. preoperative gait analysis, 4. no other disorder leading to gait deviations. All children were investigated clinically and classified according to the modified Harris Hip Score (mHHS) [4]. 3D-gait-analysis was performed with a VICON 512 system. Patients walked at a self-selected speed – barefoot. Spatiotemporal, kinematic and kinetic parameters were evaluated and compared to the preoperative data and to a group of normal children (n = 30, 14 ♂, 16 ♀, average age 8,1 ys.). In addition a comparison involved vs. uninvolved side was performed. The gait patterns in frontal plane were categorized according to Westhoff et al. [1]. The age at time of surgery was 8 $\pm$ 1,7 ys (5-11), the follow-up time was 4,2 $\pm$ 2,0 ys (2-7,5)

RESULTS

In comparison to the preoperative status the mHHS improved significantly and ranged within normal values. Analysis of the spatio-temporal parameters showed significantly increased gait velocity ($p=0,017$), increased step-length on the involved side ($p<0,001$) and a normalized limp-index ($p=0,020$). ROM of the pelvis ($p<0,001$) and the maximum anterior tilt of the pelvis ($p=0,001$) decreased to normal values. At the hip ROM ($p<0,001$) in the sagittal plane increased due to increased hip extension ($p<0,001$) to normal values. Comparison of the kinematics uninvolved vs. involved side showed a completely normal symmetric movement pattern in the sagittal and frontal plane on average. Analysis of the frontal plane gait pattern revealed an overall improvement – while preoperative 10 patients showed a Duchenne-like pattern this was the case postoperatively only in 3. Power analysis of the hip joint revealed an increase in power generation to normal values ($p=0,01$). Analysis of the hip flexor index according to Schwarz normalized in all but one patients.

DISCUSSION & CONCLUSIONS

After containment improving surgery gait analysis demonstrated significant improvement of the gait pattern with regain of gait symmetry. 3D-gait analysis enables the analysis of the functional outcome of different treatment options after LCPD. Further studies are necessary to determine the functional predictors for the development of secondary osteoarthritis which may be influenced by conservative or surgical treatment options.

REFERENCES

[1] Westhoff et al.; Computerized gait analysis in LCPD - analysis of the frontal plane. Gait Posture 2006, 24, 196 – 202

[2] Westhoff et al.: Correlation of functional outcome and X-ray-findings after Perthes disease. Int Orthop 2011, 35, 1833-37

[3] Westhoff et al.: Computerized gait analysis in LCPD - analysis of the sagittal plane. Gait Posture 2012, 35, 541-6

[4] Byrd, Jones: Hip arthroscopy in the presence of dysplasia. Arthroscopy 2003, 19, 1055-60

O03

PREDICTORS OF COMPENSATORY AND ADAPTIVE TRUNK MOVEMENTS DURING GAIT IN CHILDREN WITH ARTHOGRYPOSIS MULTIPLEX CONGENITA

Harald Böhm[1], Christel Multerer[1] and Leonhard Döderlein[1]

[1]Behandlungszentrum Aschau GmbH, Orthopaedic Hospital for Children , Aschau im Chiemgau, Germany

INTRODUCTION

Arthrogryposis multiplex congenita (AMC) is a heterogeneous condition which is characterized by multiple congenital contractures and muscular deficits in multiple body areas. During walking increased compensatory movements of the pelvis and thorax have been reported [1]. Excessive movements between thorax and pelvis might cause degenerative changes in the intervertebral discs and in consequence low back pain [2]. Therefore the aims of this study were first, to quantify pathological trunk movements during gait in children with AMC and second, to calculate predictors for increased trunk movements.

PATIENTS/MATERIALS and METHODS

29 patients 10±5 years were included in the study. 19 were diagnosed as Amyoplasia (AA), 10 with distal Arthrogryposis (DA), 15 typically developed children (TD) were used as controls. Pelvic, thorax and spine mean sagittal flexion; range of frontal lean and range of transverse rotation during gait were analyzed (ANOVA between AA, DA and TD). Range of motion and strength of the hip knee and ankle joints from clinical tests their corresponding gait parameters were included in a stepwise multiple linear regression analysis.

RESULTS

Patients with AA showed significantly increased pelvic and thorax movements in all three planes of motion (all $p<0.001$). Patients with DA showed only significantly increased anterior pelvic tilt in the sagittal plane ($p<.001$). For both patients groups only in the sagittal plane the spine was significantly more extended (AA: $p=.002$, DA: $p<0.001$). For patients with AA, passive hip extension, hip flexion strength and knee extension together with hip flexion explained 33%, 39% and 60% of the variance in pelvic sagittal tilt, frontal lean and transverse rotation respectively. For patients with DA increased knee flexion during stance phase of gait explained 42% of pelvic anterior tilt.

DISCUSSION & CONCLUSIONS

Our results suggest that increased trunk movements in patients with AA were compensatory for reduced step length and foot clearance. Whereas increased anterior pelvic tilt in patients with DA was suggested to be adaptive to the increased knee flexion during gait.

Increased hyperlordosis caused by pelvic anterior tilt might increase the risk of developing back pain. Therefore treatment should focus on pelvic anterior tilt, helping AMC children to develop into an adult without developing back pain.

REFERENCES

[1] Eriksson M et al. (2010) J Child Orthop 4:21-31.

[2] Beckers L et al. (1991) Acta Orthop Belg 57:198-202.

O04

BOTULINUM TOXIN A DOES NOT IMPROVE CAST TREATMENT FOR IDIOPATHIC TOE-WALKING- A PROSPECTIVE RANDOMIZED TRIAL.

Pähr Engström[1], Åsa Bartonek[1], Kristina Tedroff[1], Yvonne Haglund-Åkerlind[1], Christina Orefelt[1] and Elena M Gutierrez-Farewik[2]

[1]Karolinska Institutet, Department of Women's and Children's Health, Stockholm, Sweden
[2]Royal Institute of Technology, KTH Mechanics, Stockholm, Sweden

INTRODUCTION

Many treatments have been suggested for idiopathic toe-walking (ITW), such as casting, alone or in combination with botulinum toxin-A (BTX). Combined treatment with casting and BTX has become more common despite few studies of its efficacy and safety. It is also unknown whether treatment outcome differs in children with ITW and co-existing neuropsychiatric problems.

Our aims were to conduct a randomized controlled trial to test the hypotheses that a combination of BTX and casting is more effective than casting treatment alone in reducing toe-walking in 5-15 year old children, and that overall treatment effect correlates to extent of co-existing neuropsychiatric problems.

PATIENTS/MATERIALS and METHODS

All consecutively admitted ITW patients to the pediatric orthopedics department between November 2005 and April 2010 were considered for inclusion. Forty-seven children constituted the study population.

Children were randomized to either 4-week treatment with below knee circular casts either as the sole treatment or 1-2 weeks after undergoing injections with 12 units/kg bodyweight BTX in the calves.

Before treatment, and 3 and 12 months after cast removal, all children underwent 3-D gait analysis. Classification of ITW severity based on the gait analysis was performed and parents were asked to rate the time their child spent on toes during barefoot walking. Passive range of motion in hip, knee and ankle joints was measured with a goniometer and ankle dorsiflexor strength was measured with a hand-held dynamometer. Before treatment all children were evaluated with a screening questionnaire for neuropsychiatric problems.

RESULTS

No significant differences were found in any outcome parameter between the groups before treatment or at 3 or 12-month follow-ups. In both groups, several gait analysis parameters, passive range of motion and ankle dorsiflexor strength improved significantly both after 3 and 12 months. Treatment outcome was not correlated to co-existing neuropsychiatric problems.

DISCUSSION & CONCLUSIONS

Adding BTX injections prior to casting treatment for ITW does not improve the treatment outcome of cast-only treatment.

REFERENCES

O05

OUTCOME OF 23H BRACING FOR TIP-TOE-WALKING CHILDREN WITH CEREBRAL PALSY

Andreas Kranzl[1], Robert Csepan[2], Christian Grasl[3] and Franz Grill[2]

[1]Orthopaedic Hospital Speising, Vienna, Laboratory for Gait and Movement Analysis, Vienna, Austria
[2]Orthopaedic Hospital Speising, Vienna , Department of Pediatric Orthopaedics , Vienna, Austria
[3]Fa. Pohlig/Tappe, Vienna, Austria

INTRODUCTION

One of the most common problems in patients with Cerebral palsy is the deterioration of the musculoskeletal system, especially the legs and feet, manifested in tip toe walking. As conservative treatment there are orthopaedic shoes, splints, physiotherapy used and in more severe cases injections of Botulinumtoxin in combination with serial casting to avoid operation. Fulltime-Bracing with orthopaedic devices is one option. Aim of the study was to proof the functional outcome orthopaedic dynamic orthotics

PATIENTS/MATERIALS and METHODS

A total of 10 children with CP, hemi- or diplegic, mean age 9.3 (±2.4) years were included. Exclusion criteria were fixed ankle contractures. All patients were free ambulating, tip-toe-walking before the first examination and treatment. GMFCS classification ranged from I-II. Patients were adjusted with dynamic ankle foot orthosis including the ring shaped foot support developed by Baise/ Pohlig [1]. 3D-Gait-Analysis has been done to discriminate differences before treatment and after 3 months. No orthosis was worn during the analysis. Kinematic and kinetic parameters were calculated, as well as time-distance-parameters. Normal distribution was assessed and paired T-test (two-tailed) was used to determine statistical significance.

RESULTS

No statistical differences were found for gait velocity, cadence. Walking speed tends to be reduced at the second gait analysis. Step length reduced significantly ($p=0.027$). All patients changed their initial contact from toe to heel. Ankle joint ROM improved significantly ($p=0.001$). Improvements in the knee-joint in sagittal plane like the reduction of hyperextension in mid stance ($p=0.000$), better max. knee flexion timing ($p=0.009$) and increased maximal knee-flexion in swing ($p=0.024$). Maximum of ankle moment was increased ($p=0.003$). Maximal ankle-power increased significant ($p=0.001$). Foot progression angle showed a tendency to normalize but not statistical difference.

DISCUSSION & CONCLUSIONS

This study shows the positive effect of bracing with night-and-day splints for 23 hours. A long wearing time of the splints, nearly 24h per day for 3 months in combination with the design of the orthosis are the key features. No deteriorations were seen. The ankle joint pattern towards to improve to normal. The slightly reduced walking speed, slightly increased ankle power at push off and a better foot progression angle indicate a better functional outcome. The question is how long can this improvement be maintained? Especially high standard deviation is present at pelvis rotation and foot progression angle. For further studies, the sample size should be increased. 23h bracing with splints showed significant improvements concerning gait parameters and can be recommended as a treatment option.

REFERENCES

[1] Baise, M Behandlung des reversible dynamischen Spitzfußes mittels Unterschenkelorthesen mit ringförmiger Fußfassung, Ergebnisse bei Kindern mit infantiler Zerebralparese. Med. Orth. Tech. 3

10.00 - 10.30	**COFFEE IN THE EXHIBITION HALL**
10.30 - 11.15	**BAUMANN LECTURE, Carlo Frigo, Assoc. Professor, PhD. Department of Bioengineering of Politecnico di Milano, Italy.** Analysis and synthesis of human locomotion (A2)

Curriculum Vitae of Carlo Frigo

Carlo Frigo has been working in the area of movement analysis and motor control since 1976, when he has graduated at Politecnico di Milano. His background is biomechanical engineering, although the group in which he has been involved is a multidisciplinary group, which includes electronics, informatics, automatics.
His academic position is Associate Professor at the Faculty of System's Engineering, and he belongs to the Department of Bioengineering of Politecnico di Milano. He has been working for 25 years in the Bioengineering Centre of Milan, that was an institutional cooperation between Politecnico di Milano and Fondazione Don Gnocchi, one of the major rehabilitation and research institutes in Italy. In this frame he has been active part in the development of one of the renowned systems for movement analysis, the ELITE System.

He has also contributed to realize one of the first clinically oriented Gait Analysis laboratories: the SAFLo (Servizio di Analisi della Funzionalità Locomotoria). SAFLo is also the acronym of a gait analysis protocol that he has developed and that is now implemented in several gait analysis systems. Carlo Frigo has contributed to the constitution of the Italian Society for Clinical Movement Analysis (SIAMOC) of which he has been the first Secretary (years 1999-2003) and then President from 2007 to 2009. He has been active member of ESMAC, organizer of the 10th ESMAC congress in

Rome, 2001, held jointly with SIAMOC, and has been part of the ESMAC Committee. His present interests, beside clinical movement analysis and movement biomechanics, are musculoskeletal modelling, computer simulation, and all related applications in the field of orthotics and prosthetics, functional surgery, motor control and recovery of motion.

Abstract of this year's Baumann lecture

Analysis and Synthesis of human locomotion

Analysis of human movement has evolved from early applications of technology, that were pioneered in the seventies/eighties of the last century, to current applications in which movement analysis is performed routinely in many clinical laboratories. Biomechanical variables and neuromotor control have been investigated deeply since then, and useful information from the clinical point of view can now be obtained in individual subjects, and allow planning interventions and check the functional status of a patient.

More recently the possibility to model the musculoskeletal system and simulate human movement has opened new perspectives to understanding the motor behaviour. Synthesis is the process of building a product by adding its constitutive components. Movement can be synthesized by properly combining input variables that control the degrees of freedom of a model. These variables can be joint angles and space coordinates, but also joint moments, muscle forces, environmental conditions. Integration of the two processes of analysis and synthesis can improve our capability to investigate complex mechanisms.

A typical problem we can face in this way is the 'what if' problem. The effects of changing muscle length and insertion points, changing the properties of muscle contraction, or patterns of muscle recruitment, for example, can all be investigated by this approach. In addition the function of muscles, in particular the double-joint ones, and the synergistic control of agonists and antagonists can be investigated in some specific conditions and better understood. It is foreseen that several aspects related to treatment of neuromotor disorders will be dramatically enhanced when models for simulating complex dynamic phenomena will be available with sufficient accuracy and ability to adapt to single individuals.

11.15 - 12.00	**SESSION 2a (A2)** **Imaging methods** **Chairmen: Caroline Stewart, Reinald Brunner**
O06 Sangeux, Morgan	Do physical examination and CT-scan measures of femoral neck anteversion and tibial torsion relate to each other?
O07 van der Krogt, Marjolein	Subject-specific musculo-tendon parameters based on MRI and dynamometer tests
O08 Passmore, Elyse	Gait kinematics and radiographic deformity following Slipped Upper Femoral Epiphysis
O09 Weimann-Stahlschmidt, Kristina	Correlation of radiological outcome and gait function of SCFE patients after growth arrest
11.15 - 12.00	**SESSION 2b (C4)** **Knee Osteoarthritis** **Chairmen: Per Wretenberg, Josien van den Noort**
O10 Scheys, Lennart	Functional knee joint assymetry in subjects with Unilateral Knee Osteoarthritis: An analysis of 11 different motor tasks.
O11 Naili, Josefine	3D evaluation of the single limb mini squat test in patients with Knee Osteoarthritis

O12 Rätesepsoo, Monika	Relationship between leg extensors strength, postural-stability and risk of falling in women with Gonathrosis after 2-months home exercise program
O13 Turcot, Katia	Influence of knee alignment on gait in patients with Knee Osteoarthritis

O06

DO PHYSICAL EXAMINATION AND CT-SCAN MEASURES OF FEMORAL NECK ANTEVERSION AND TIBIAL TORSION RELATE TO EACH OTHER?

Morgan Sangeux[1] and H. Kerr Graham[1]

[1]Royal Children's Hospital, Hugh Williamson Gait Analysis Laboratory, Melbourne, Australia

INTRODUCTION

Gait analysis is crucial in the functional assessment of gait impairments. It complementes physical examination (PE) which looks at the impairments from an anatomical point of view. The PE measures the joints' range of movement, to estimate muscle contracture or spasticity, and bony alignment to estimate torsional deformities. The surgical decision for derotation of the femur or the tibia requires two conditions to be fulfilled: an abnormal bony torsion and a functional impairment due to this torsion. However, since contradictory results have been reported about the validity of the PE estimate of the femoral neck anteversion (FNA) and the tibial torsion (TT), [1-3], surgical decision about derotation of the femur and/or tibia may require CT-scans. The purpose of this study was to assess the agreement between the PE and CT-scan measures of FNA and TT.

PATIENTS/MATERIALS and METHODS

A retrospective cohort of patients presenting abnormal PE estimates of their FNA was extracted from our database. The selection criteria for the patients were a maximum internal hip rotation greater than 65°, a maximum external hip rotation less than 35° and a trochanteric prominence angle test (TPAT, [1]) greater than 25°. The patients should have had a CT-scan measurement of the FNA and TT less than 6 months before or after the gait analysis.

RESULTS

Results on 60 subjects for FNA and 43 for TT were obtained (table below). The PE measures were significantly (*: $\alpha<0.1$) smaller than the CT-scan measures. Linear correlations between PE and CT-scan measures were significant. Correlation for FNA was weak (R^2=12%) but good (R^2=61%) for TT. Although weak (R^2=35%), the best PE measure to predict the CT-scan FNA was not the TPAT but the midpoint between the maximum internal and external rotation range of the hip.

		FNA	TT
	N subjects (N limbs)	60 (120)	43 (86)
CT-Scan	Mean (SD)	33 (14)	36 (12)
Difference PE - CT	Mean (SD)	-5 (13)*	-16 (8)*
	Range	[-41,30]	[-31,3]
Correlation CT = f(PE)	linear regression R^2	12%	61%
	Constant	9.5	15.4*
	Slope	0.83*	1.03*

DISCUSSION & CONCLUSIONS

This study has shown that major discrepancies exist between the PE and CT-scan measures of lower limb bony torsion, especially for femoral neck anteversion. Given the clinical impact that these deformations have on the surgical decisions taken, further research is required to develop reliable measurements at the time of the gait analysis.

REFERENCES

[1] Ruwe PA, et al. Clinical determination of femoral anteversion. A comparison with established techniques. JBJS 1992;74(6):820-30. [2] Davids JR, et al. Assessment of femoral anteversion in children with cerebral palsy: Accuracy of the trochanteric prominence angle test. JPO. 2002;22(2):173-8. [3] Milner CE et al. A comparison of four in vivo methods of measuring tibial torsion. JA. 1998;193(01):139-44.

SUBJECT-SPECIFIC MUSCULO-TENDON PARAMETERS BASED ON MRI AND DYNAMOMETER TESTS

Vincenzo Carbone[1], Marjolein M. Van der Krogt[1], Bart F.J.M. Koopman[1] and Nico Verdonschot[1]

[1]University of Twente, Laboratory of Biomechanical Engineering, Enschede, The Netherlands

INTRODUCTION

Subject-specific musculo-skeletal (MS) models are essential to reliably predict the effects of surgery on individual patients. Unfortunately, musculo-tendon (MT) parameters, which greatly affect model force predictions [1], are difficult to measure directly and are known to vary with age, gender and activity. The aim of this study was to estimate subject-specific MT parameters (tendon slack length, optimal muscle fiber length, and maximal isometric muscle force) of the lower extremity, by using functional scaling based on segmented MRI scan and dynamometer tests.

PATIENTS/MATERIALS and METHODS

We used the Twente Lower Extremity Model (TLEM) [2], implemented in the AnyBody Modeling System (version 5.1) (www.anybodytech.com). TLEM consists of 12 body segments, 11 joints and 21 DOFs, each leg containing 163 Hill-type MT elements. The model was scaled to one example subject. First, MT parameters were scaled according to the subject's height and weight. Second, muscle volumes were estimated based on a segmented MRI scan of the subject, using Mimics software (www.materialise.com/mimics). Third, MT parameters were optimized so that the model reproduced subject-specific strength profiles measured during a complete set of isometric and isokinetic maximal voluntary contractions (MVC), under the assumption that during MVC predicted muscle activity should be equal to 100% (Fig. 1).

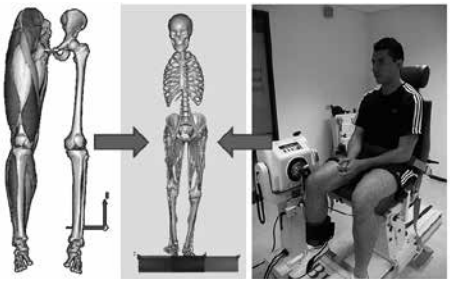


Figure 1: Subject-specific musculo-skeletal model (center) based on segmented MRI scan (left) and dynamometer tests (right).

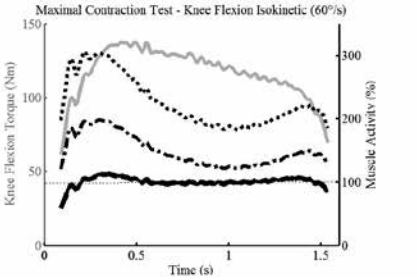


Figure 2: Knee flexion torque (grey) and knee flexor muscle activity (min-max criterion) after anthropometric (dotted), muscle volume (dash-dot) and functional (solid) scaling.

RESULTS

Model predictions became much more realistic after functional scaling. For instance, muscle activity necessary to reproduce measured knee flexion torque was too high after anthropometric (~300%) and muscle volume (~200%) scaling, but it improved drastically after functional scaling (~100%) (Fig. 2). Similar results were found for other joints.

DISCUSSION & CONCLUSIONS

The proposed functional scaling of MT parameters, based on MRI and dynamometer tests, was successful in achieving more reliable model outcomes, while simple anthropometric and muscle volume scaling were inadequate and caused unrealistic muscle activity prediction. Next, image-based muscle attachment sites will permit to further reduce errors in muscle force predictions [3] and hence improve the reliability of subject-specific model.

REFERENCES

[1] Carbone *et al*, Proceedings of XIII TGCS International Symposium, Leuven, Belgium, 2011.

[2] Klein Horsman *et al*, Clinical Biomechanics 22 (2007), pp. 239-247.

[3] Carbone *et al*, Proceedings of XXIII ISB Congress, Brussels, Belgium, 2011, pp.18/37.

O08

GAIT KINEMATICS AND RADIOGRAPHIC DEFORMITY FOLLOWING SLIPPED UPPER FEMORAL EPIPHYSIS

Elyse Passmore[1], Morgan Sangeux[1], Glenn Gomez[1], Jitendra Balakumar[1], Susan Donath[1], Adrienne Fosang[1] and Kerr Graham[1]

[1]Royal Children's Hospital, Melbourne, Australia

INTRODUCTION

Slipped upper femoral epiphysis (SUFE) results in hip deformity and femoro-acetabular impingement (FAI). FAI affects hip motion and impacts on gait. The purpose of this study was to quantify the effects of moderate to severe SUFE on 3D gait kinematics and to determine if there were correlations between gait deviations and slip severity.

PATIENTS/MATERIALS and METHODS

Patients referred to the Royal Children's Hospital for a 3D gait analysis (3DGA) between 2000 and 2009 after pinning in situ of a stable SUFE, were studied retrospectively. Inclusion criteria were unilateral SUFE, Southwick Lateral Slip Angle (LSA) ≥ 30°, [1], no surgical complications, appropriate hip and pelvis radiology and 3DGA. 3DGA was performed with a Vicon motion system (OMG, UK) and followed the Plug in Gait (VICON, UK) protocol. Gait Variable Score (GVS) and Gait Profile Score (GPS), [2], were calculated on the study cohort for both the sound and slipped side, compared to 38 paediatric subjects with no gait pathology (NGP), using t-test with unequal variances ($\alpha = 0.05$) in Minitab (Minitab, Inc., USA).

RESULTS

30 Patients (17 Male, 13 Female), with an average age at pinning of 13.3years (±1.9years) were included. The average LSA, Klein's line offset and alpha angle of Noztli were 45.3° (±13.0°), -6.4mm (±8.0mm) and 113.6°(±13.1°) respectively. The GPS and all GVS, except Pelvic Tilt (sound and slip side) and Foot Progression (sound side), were significantly different compared to the NGP group. Hip Rotation and Foot Progression GVSs as well as GPS were significantly different between the slipped and sound sides. However, no significant correlations were found between GVSs and the radiological measurements.

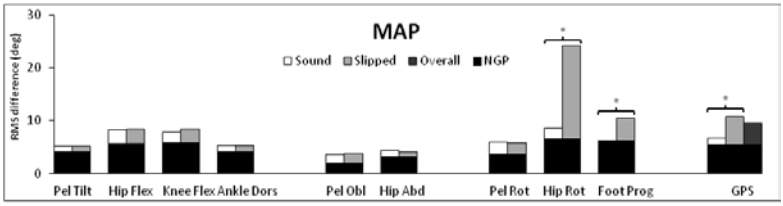


Figure 1 – MAP and GPS for slip and sound sides verses normal. All GVS's were significant (α=0.05) compared to normal except Pelvic Tilt(slipped and sound) and Foot progression(sound side). * Slipped verses sound side is significant (α=0.05).

DISCUSSION & CONCLUSIONS

This is one of the few studies, [3], which quantifies gait deviations in adolescents with moderate/severe stable unilateral SUFE. Our results show marked abnormalities of hip morphology as determined by radiological data. GVSs and GPS showed deviation from normal for most variables and most markedly for the Hip Rotation GVS. No relationship between the radiological measurements and GVSs or GPS was found. Future research will focus on relationships between selective parameters of the gait pattern (ex: Mean hip rotation, Range of Pelvis rotation, etc.) and radiological data.

REFERENCES

[1] Dawes, B., et al. (2011). Radiographic Assessment of Bone Remodelling in SUFE Using Klein's Line and the a Angle of Femoral-Acetabular Impingement: A Retrospective Review. J Pediatr Orthop 31(2): 153-58.

[2] Baker, R., et al. (2009). The Gait Profile Score and Movement Analysis Profile. Gait & Posture 30(3): 265-69.

[3] Song, K. M., et al. (2004). Gait abnormalities following SCFE. J Pediatr Orthop 24: 148-55.

O09

CORRELATION OF RADIOLOGICAL OUTCOME AND GAIT FUNCTION OF SCFE PATIENTS AFTER GROWTH ARREST

Kristina Weimann-Stahlschmidt[1], Katharina Ruhe[1], Christoph Zilkens[1], Reinhard Willers[1], Ruediger Krauspe[1] and Bettina Westhoff[1]

[1]University of Duesseldorf, Medical Faculty, Department of Orthopaedics, Duesseldorf, Germany

INTRODUCTION

Slipped capital femoral epiphysis (SCFE) represents the most common affection of the hip in adolescents and a preliminary stage of degenerative joint disease. Reliable tools for outcome evaluation have to be developed. Up to now only subjective clinical and radiological findings are analyzed. Functional aspects are almost not taken into account (1). Radiological examination findings routinely used for evaluation to date are compared with functional results gained by 3-D gait analysis (GA). Discrepancy of functional outcome and radiological findings after growth arrest is hypothesized.

PATIENTS/MATERIALS and METHODS

37 SCFE patients after growth arrest (18.5 years, SD 4.61) with unilateral SCFE were included. In all patients surgery was performed at average age 13.2 years (10-15.9). Average age at time of follow up was 18.8 years (13.3-32). Average slipping angle was 31° (8°-60°). Clinical results were classified according to the radiological index of Heyman and Herndon (HH) (2) and to asphericity according to Mose. 3D-GA-parameters were generated with a VICON 512 system. The subject, walked at a 10m walkway bare footed at self selected speed. Subgroup analysis was performed according to radiological results.

RESULTS

The radiological findings revealed very good results in general (average comprehensive index of Heyman and Herndon 94 ± 9%, asphericity grade <2). For the HH Index only the head neck quotient was considerably decreased (mean 84 ± 13%) indicating a shortening and thickening of the patients´ femoral neck on slip side. Asphericity measurements in ap-view revealed an average asphericity of grade 1.6 ± 1.2 on slip side and 1.3 ± 1.1 on sound side. The difference was not statistically significant. Imhaeuser radiographs displayed an average asphericity of grade 1.2 ± 1.0 on slip side and of grade 0.7 ± 1.0 on sound side. In this plane the difference was statistically significant ($p=0.04$). Significant deviations of gait parameters in relation to radiological result were an increase in step width (0.19/0.14, $p=0.005$), sagittal ROM of the pelvis (3.2/2.3, $p<0.001$) and foot progression (-17.2/-7.5, $p<0.001$) for the worse subgroup. There was no significant difference for gait velocity, cadence and duration of the different phases of the gait cycle (stance, single stance, double stance, swing phase) between the radiological subgroups “excellent” and “good or fair”. The worse radiological subgroup revealed a significant bigger BMI at time of surgery compared to the better subgroup (27.4 ± 3.6 kg/m² vs. 23.4 ±3.4kg/m², $p=0.01$). At follow-up after growth arrest the difference was nearly equalized. By then the BMI of both subgroups could be classified as obese (26.1 ± 4.2 kg/m² vs. 27.7 ± 4.0kg/m²).

DISCUSSION & CONCLUSIONS

In order to investigate the influence of radiological outcome on SCFE patients´ gait subgroup analysis was performed. Basically radiological findings matched functional results gained by 3D-gait analysis. Functional outcome varied slightly depending on the radiological findings after growth arrest. Differences were most pronounced for foot progression. Only with the help of GA it was possible to describe deviations more precisely. Further studies with longer follow up have to show which functional deviations are relevant for the development of osteoarthritis and might be influenced by conservative or operative treatment.

REFERENCES

1. Westhoff B., Ruhe K., Weimann-Stahlschmidt K., Zilkens C, et al. (2011) The gait function of slipped capital femoral epiphysis in patients after growth arrest and its correlation with the clinical outcome. Int Orthop. Nov. 24

2. Heyman C.H.,Herndon C.H. (1950) Legg-Perthes Disease: A Method for the Measurement of the Roentgenographic Result. J Bone Joint Surgery Am. 32-A: 767-778.

O10

FUNCTIONAL KNEE JOINT ASSYMETRY IN SUBJECTS WITH UNILATERAL KNEE OSTEOARTHRITIS: AN ANALYSIS OF 11 DIFFERENT MOTOR TASKS

L. Scheys[1], H. Vandenneucker[2], B. Callewaert[3], P. Mertens[4], K. Brabants[4], J. Bellemans[2] and K. Desloovere[3]

[1]Smith & Nephew, European Centre for Knee Research, Leuven, Belgium
[2]K.U. Leuven, Department of Orthopedics and Traumatology, Univ. Hosp. Pellenberg, Leuven, Belgium
[3]K.U. Leuven, C-MAL Pellenberg, Department of Rehabilitation Sciences, Leuven, Belgium
[4]Algemeen Ziekenhuis Middelheim, Department of Orthopedics, Antwerp, Belgium

INTRODUCTION

Left-right symmetry in joint function is a frequently studied aspect of human motion. With a specific reference to knee osteoarthritis (OA) however, very few studies include the contralateral unaffected limb in their analysis and therefore there is a paucity of data relating to the symmetry in this subject group [1]. Although contemporary knee arthroplasty designs aim to restore natural knee kinematics during daily living [2], even fewer studies analyze left-right asymmetry during multiple motor tasks. Therefore the objective of this study was: (1) to analyze the kinematic and kinetic symmetry in persons with unilateral knee OA during a wide range of daily-life motor-tasks and (2) to analyze through an additional comparison with matched healthy controls to what extent both limbs replicate normal knee biomechanics.

PATIENTS/MATERIALS and METHODS

Ten subjects diagnosed with unilateral symptomatic primary knee osteoarthritis participated in this study (Sex: 5M, 5F; 5 right-/5 left-affected; Age: 62.8±7.3y; Height: 1.72±0.08m; BMI: 26.2±1.7; KL-grade 3.6±0.5). During one single motion analysis session each subject performed 11 different motor tasks with 3 repetitions each: walking (W), W followed by a crossover (WCO)/sidestep turn (WSS), ascent onto a step (SA), descent off a step (SD), SD followed by a crossover (SDCO)/sidestep turn (SDSS), mild (MiS) or maximum squat (MaS), chair rise (CR) and lunge (L). In addition, data from 10 healthy control subjects (matched on age, sex and BMI) were included from the labs' reference database.

RESULTS

The analysis revealed statistically significant bilateral kinematic asymmetries between the subjects' involved and non-involved side for a large range of motor tasks, with the non-involved side much more closely matching healthy controls' knee joint function. E.g., compared to the non-affected side peak knee flexion angles during stance were significantly reduced at the involved side during W (mean %-difference: 16%), WCO (18.4%), WSS (11.2%), SD (14.6), SDCO (26.6%) and SDSS (22.9%). Similarly, peak flexion angles during lunge were reduced by an average of 4.1% at the involved vs. non-involved side. In contrast there was no significant difference at the non-involved side vs. healthy controls. Despite a clear assymetry in knee joint loading during left-right synchronized high-loading motor tasks, i.e. MiS, MaS and CR, there was no significant reduction in peak flexion angle. Furthermore we found a significant systematic offset towards external knee rotation which was consistent throughout the entire cycle of all analyzed motor tasks at the involved vs. non-involved side, but not at the non-involved side vs. healthy controls.

DISCUSSION & CONCLUSIONS

This study demonstrates that individuals with knee OA exhibit interlimb asymmetry by significantly changing knee kinematics and kinetics in their affected limb across a large range of daily life activities. Squat and chair rising highlighted the strategy for reduced knee loading on the affected side, while keeping the knee kinematics symmetrical. The lack of apparent differences between the unaffected side and controls suggests the absence of severe compensation signs in knee kinematics.The collected data has the potential to provide a better understanding of compensation strategies in OA subjects and their relevance for the further progression of OA at both the affected and unaffected limb.

REFERENCES

[1] Zeni JA and Higginson JS,The Knee;18(3):156-9. [2] Catani F et al., J of Orthop Res.; 27:1569-75.

O11

3D EVALUATION OF THE SINGLE LIMB MINI SQUAT TEST IN PATIENTS WITH KNEE OSTEOARTHRITIS

Josefine E Naili[1], Elena M Gutierrez-Farewik[2], Mikael Reimeringer[3], Anna-Clara Esbjörnsson[1] and Eva W Broström[1]

[1]Karolinska Institutet, Women's and Children's health, Stockholm, Sweden
[2]Royal Institute of Technology, KTH Mechanics, Stockholm, Sweden
[3]Karolinska University Hospital, Motion Analysis Laboratory, Stockholm, Sweden

INTRODUCTION

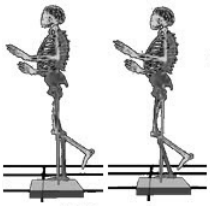
The maximum number of single limb mini-squats (SLMS) during 30 seconds is a valid and reliable test for patients with knee osteoarthritis (OA) [1]. The test requires neuromuscular control and the ability to quickly change between concentric and eccentric work of the muscles in hip and knee extensors. We aimed to evaluate the both the biomechanical aspects of the SLMS test in addition to the quantity of repetitions.

PATIENTS/MATERIALS and METHODS

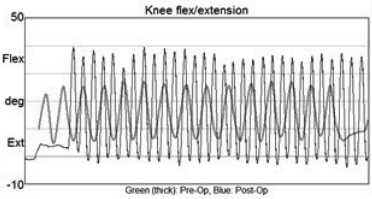
10 patients with knee OA were included. Preoperative assessments were performed within a month prior to total joint replacement surgery (TJR) and one-year post operatively. Preoperatively, the subjects' were 65.1±7.2 yrs, with body mass index of 30.2±5.2. Data was gathered with an 8 camera motion analysis system and the Plug-in-Gait model (Vicon). The patients were asked to flex the knee approximately 30° and then fully extend (see figure). Maximum number of SLMS performed during 30 s on each leg was recorded. Patients rated their perceived pain during the SLMS test with a visual analogue scale (VAS 0-100mm). Motion analysis parameters from one squat after at least 20 s were used for the analysis.

RESULTS

Limb Symmetry Index (ratio of repetitions on the OA leg to the healthy leg) increased with 22.4% after surgery to 94.7% and number of SLMS increased from 13.7 ±5.4 to 19.8±3.7 in the affected leg. The patients' knee flexion range of motion increased by an average of 13 degrees (see figure), anterior trunk tilt decreased, hip abduction moment increased, and positive and negative work done at the knee increased. Pain assessment decreased after surgery from 51mm to 13 mm after surgery.



Mini-squat



Knee flexion during 30 s

DISCUSSION & CONCLUSIONS

Patients were clearly able to use their available muscle strength to perform the mini-squats after TJR to a larger extent and more quickly. Several compensatory mechanisms observed pre-operatively vanished; pre-operative compensatory movements ranged from lateral trunk lean combined with contralateral pelvic elevation to anterior trunk tilt combined with contralateral pelvic drop. The mini-squat test complements conventional gait analysis in patients with knee OA by placing higher demands for loading, movement and stability on the affected knee, and may be a more sensitive test to evaluate surgical outcome.

REFERENCES

[1] Bremander AB et al. Scand J Med Sci Sports. 2007;17:120-127

O12

RELATIONSHIP BETWEEN LEG EXTENSORS STRENGTH, POSTURAL STABILITY AND RISK OF FALLING IN WOMEN WITH GONARTHROSIS AFTER 2-MONTH HOME EXERCISE PROGRAM

Monika Rätsepsoo[1], Helena Gapeyeva[1], Jelena Sokk[1], Jaan Ereline[1], Tiit Haviko[2], Aare Märtson[2], Mati Pääsuke[1] and Enn Seppet[3]

[1]Institute of Exercise Biology and Physiotherapy, University of Tartu, Tartu, Estonia
[2]Department of Traumatology and Orthopaedics, University of Tartu, Tartu, Estonia
[3]Institute of General and Molecular Pathology, University of Tartu, Tartu, Estonia

INTRODUCTION

The effect of home exercise programs (HEP) before total knee arthroplasty (TKA) in women with late stage gonarthrosis has not been sufficiently researched. The aim of this study was to investigate the relationship between leg extensors muscle strength, postural stability and risk of falling in women with late stage gonarthrosis, scheduled for TKA after 2-month HEP.

PATIENTS/MATERIALS and METHODS

Ten women with gonarthrosis aged 46-72 years who were scheduled for unilateral total knee arthroplasty (TKA) participated in this study twice: before conducting home exercise program (HEP) and 2 months after performing HEP. All patients performed HEP daily during 2 months (average duration of 25 minutes a day) which included resistance and balance exercises. Isometric maximum voluntary contraction (MVC) of leg extensors was measured with a custom-made leg bench, postural stability characteristics were recorded on force plates (eyes open, during 30 seconds) and falling risk was estimated with a questionnaire.

RESULTS

Significant improvement in unilateral peak torque (PT) of the involved leg ($p<0.01$; increased by 67.5%) and bilateral PT ($p<0.001$, increased by 37.9%) was found after 2 months of HEP. Patients had an increase in PT:body mass (PT:BM) ratio ($p<0.05$; increased by 72.3%) of the involved leg and bilateral PT:BM ratio ($p<0.001$, increased by 37.2%) after 2-month HEP. PT and PT: BM ratio of the involved leg were significantly lower compared to the uninvolved leg ($p<0.05$) before HEP, but not after HEP. Center of pressure (COP) sway characteristics (anteroposterior and mediolateral displacement, trace length and area) did not differ significantly after 2-month HEP. A medium negative correlation ($p<0.05$) was found between anteroposterior sway and leg extensors muscle strength before and after HEP ($p<0.05$) and a medium positive correlation between leg extensors muscle strength and falling risk before HEP.

DISCUSSION & CONCLUSIONS

It has been established that patients with gonarthrosis experience decreased postural stability and muscle strength (Hurley et al., 1997; Hassan et al., 2001). In the present study after 2-month HEP leg extensors muscle strength increased remarkably in women with late stage gonarthrosis; whereas no changes were found in postural stability. The results of the present study indicate that leg extensors muscle strength plays an important role in the risk of falling and postural stability in women with late stage gonarthrosis.

REFERENCES

[1]. Hassan BS, et al. Ann Rheum Dis 2001; 60: 612–618.

[2] Hurley MV, et al. Ann Rheum Dis 1997; 56: 641-648.

Acknowledgements. This study was partly supported by the Estonian Ministry of Education and Research project SF0180030s07, Estonian Science Foundation project 7939 and EU FP7 project GA-223576.

O13

INFLUENCE OF KNEE ALIGNMENT ON GAIT IN PATIENTS WITH KNEE OSTEOARTHITIS

Katia Turcot[1, 2], Domizio Suvà[2], Anne Lübbeke[2], Daniel Fritschy[2], Pierre Hoffmeyer[2], Stéphane Armand[1, 2]

[1]Geneva University Hospitals and Geneva University, Willy Taillard Laboratory of Kinesiology, Geneva, Switzerland
[2]Geneva University Hospitals, Division of Orthopaedics and Trauma Surgery, Geneva, Switzerland

INTRODUCTION

Patients with knee OA are recognised to present an altered gait pattern that is associated with pain and disease severity [1-3]. Amongst many factors, the lower limb alignment has been identified as an important risk factor for the progression of knee OA. Based on our knowledge, no gait study has compared patients with knee OA and different knee deformities. The aim of this study was to determine how knee alignment influences full-body gait in patients with severe knee OA.

PATIENTS/MATERIALS and METHODS

Sixty patients with severe knee OA scheduled for a total knee arthroplasty (TKA) were included in this study. Patients were divided in two groups (varus and valgus). The hip-knee-ankle (HKA) angle was assessed by full-limb radiography. A knee was defined as varus when the angle was less than 180° and as valgus when the angle was greater than 180°. A 3D motion analysis system (VICON) was used to capture the full-body motion during gait. Reflective markers were placed on the pelvis and lower limbs according to the Davis protocol[4] and on the trunk as described by Gutierrez-Farewik et al.[5]. Two force plates (AMTI) were used to capture the ground reaction forces. The 3D full-body kinematics and lower body kinetics were compared between the two groups using a one-way ANOVA and Tukey post-hoc tests.

RESULTS

The analysis demonstrated different gait patterns between both groups (Tables 1-2). Patients with varus knee significantly augmented their upper body gait compensations in the frontal plane compared to patients with a valgus knee. Differences between varus and valgus groups were also obtained for knee and hip parameters.

Table 1. Comparison between varus and valgus groups for the thorax and pelvis kinematics

	VARUS (n=46)	VALGUS (n=14)	*P* value
Thorax			
Flexion mean - stance (°)	5.29 ± 6.99	5.82 ± 8.16	0.963
Flexion range - stance (°)	3.63 ± 1.33	3.13 ± 1.26	0.335
Obliquity mean - stance (°)	-1.80 ± 2.02	-0.05 ± 1.24	0.001
Obliquity range - stance (°)	5.35 ± 2.47	3.36 ± 1.53	0.007
Obliquity min (peak) - stance (°)	-3.69 ± 2.35	-1.38 ± 1.53	<0.001
Pelvis			
Tilt mean - stance (°)	12.03 ± 5.87	11.41 ± 7.64	0.932
Tilt range - stance (°)	3.37 ± 1.21	3.25 ± 1.19	0.920
Obliquity mean - stance (°)	-0.26 ± 1.94	-1.07 ± 2.43	0.274
Obliquity range - stance (°)	4.76 ± 1.90	4.05 ± 1.86	0.464

Table 2. Comparison between varus and valgus groups for the hip and knee kinematics and kinetics

	VARUS (n=46)	VALGUS (n=14)	*P* value
Hip			
Flexion mean - stance (°)	10.72 ± 7.08	10.30 ± 9.46	0.980
Flexion range - stance (°)	37.92 ± 5.46	36.20 ± 6.07	0.054
Add/Abd mean - stance (°)	1.84 ± 4.90	8.03 ± 3.96	<0.001
Add/Abd moment max - stance (Nm/kg)	0.93 ± 0.18	0.99 ± 0.14	0.340
Knee			
Flexion max - gait cycle (°)	45.42 ± 7.78	48.82 ± 8.93	0.279
Flexion range - stance (°)	41.97 ± 9.72	44.77 ± 7.72	0.495
Add/Abd mean - stance (°)	4.40 ± 6.79	-7.84 ± 6.96	<0.001
Add moment max - mid-stance (Nm/kg)	0.62 ± 0.19	0.31 ± 0.18	<0.001
Flex/Ext moment max - loading (Nm/kg)	0.22 ± 0.14	0.21 ± 0.18	0.964

DISCUSSION & CONCLUSIONS

This study examines the relevance of full-body analysis in the understanding of gait compensations in patients with severe knee OA and different knee deformities. We found that gait compensations were significantly influenced by HKA alignment. Future studies are however required to investigate gait compensations following TKA. In fact, although many studies have reported on gait modifications after TKA, little is known about the influence of HKA correction on upper body compensations following surgery.

REFERENCES

[1] M. A. Hunt, et al., Arthritis Care Res (Hoboken), vol. 62, pp. 1426-32, Oct 2010. [2] L. Sharma, et al., Arthritis Rheum, vol. 41, pp. 1233-40, Jul 1998. [3] J. L. Astephen, et al., J Orthop Res, vol. 26, pp. 332-41, Mar 2008. [4] R. B. Davis III, et al., Human Movement Science, vol. 10, pp. 575-587, 1991. [5] E. M. Gutierrez-Farewik, et al., Hum Mov Sci, vol. 25, pp. 238-56, Apr 2006.

12:00 - 13:00	**LUNCH IN THE EXHIBITION HALL**
13.00 - 14.30	**POSTER PRESENTATIONS IN EXHIBITION HALL & BALCONY**
14:30 - 15:00	**KEYNOTE SPEAKER I, Tim Theologis, MD, PhD, FRCS** **Nuffield Orthopaedic Centre, Oxford, UK** Challenges in organizing surgical trials (A2)

Curriculum Vitae of Tim Theologis

Tim Theologis studied medicine in Athens, Greece and completed his surgical and orthopaedic training in Oxford, UK. He also completed a paediatric orthopaedic fellowship at the Hospital for Sick Children in Toronto, Canada. In 1996 he was appointed at the Nuffield Orthopaedic Centre, a tertiary care hospital in Oxford, as a Consultant Orthopaedic Surgeon with special interest in children and neuromuscular disorders. He has developed a strong clinical and research link with the Oxford Gait Laboratory since.

He looks after children with orthopaedic conditions and musculoskeletal tumours, as well as neuromuscular disorders, including cerebral palsy. He is involved in the teaching of medical students, the supervision of postgraduate degrees and the training of orthopaedic residents. He has been involved in the ESMAC Committee activities since 2000 and was Chairman 2006-2010. He was appointed as Editor in Chief for Gait and Posture in 2005. The Oxford Gait Laboratory occupies a significant part of hisresearch and clinical activity.

Abstract

Challenges in organising surgical trials

Research in the field of gait analysis has led to improvements, both in the technology used and the reliability of the output available for clinical use. Scientific rigour on the part of engineers, scientists and clinicians involved in the motion analysis community has driven this field of research forward. As a result, scientific evidence supporting the reliability of gait analysis is now available and improvements have been introduced in the quality of clinical gait analysis. A recent randomized controlled trial (RCT) demonstrated that gait analysis results affect the clinicians' decision-making in the management of children with cerebral palsy (CP).

Despite the improvements in the field of gait analysis, however, the evidence to support surgical interventions to improve gait in CP remains weak. Whilst prospective randomised controlled trials, often against placebo, are common in the pharmaceutical field, designing and undertaking surgical trials is particularly challenging. In the field of CP, some good quality RCTs supported the introduction of botulinum toxin treatment in the field. However, the evidence supporting single-stage multi-level surgery is weak, being supported only by one RCT and a relatively small number of case series studies. There are numerous challenges in organising surgical trials, particularly in the sensitive patient population with CP. Attracting funding for research in this field may be challenging as the patient population is relatively small. In comparison to other orthopaedic patient populations (e.g. hip fractures in the elderly, hip and knee osteoarthritis) the impact of the CP population on health services is relatively limited. Therefore, when applying for research funds, a convincing case has to be made of the impact of treating CP on health services and the potential increase of efficiency through effective and improved treatment.

Ethical issues are often challenging in this field. Children, families and ethical committees have to be convinced that there is indeed true equipoise between two forms of surgical treatment or between an operation and conservative treatment. Surgical colleagues with established practices based on training and experience rather than evidence may also be difficult to persuade that a trial is necessary. Introducing new surgical techniques in this sensitive population may also cause ethical concerns. The practical difficulties in comparing surgical treatment against non-surgical management are obvious. Hiding surgical scars during the process and blinding assessors can be problematic, particularly during clinical examination but also in gait analysis. Placebo surgery has been used in some fields but most committees would probably consider it unethical in children with CP. Delaying surgical treatment for a pre-defined period of

time in a sub-group of patients has been suggested as a way to overcome this problem and form a control group. Defining the appropriate sample may also prove challenging. The main outcome of the trial has to be defined first and this may be controversial. The aims of the operation may include improvements in a variety of parameters, including objective gait measures, objectively measured motor function, patient perceived function, quality of life and body image. Once the main outcome is agreed, the minimum clinically important change has to be defined and calculated, if not available in the literature. The numbers that are usually necessary for an RCT are large. In most cases, it would take a single unit several years to recruit an adequate number of patients and retaining patients in the trial may also be problematic.

The length of follow-up necessary to establish the success of surgical treatment should be sufficient to allow full recovery. In the context of multilevel surgery this would translate into a minimum follow-up of two years. However, late recurrence of deformity and need for re-operation have been reported. Ideally, follow-up to skeletal maturity would, therefore, be necessary. For example, in order to establish that single-event multi-level surgery guided by gait analysis is the best option in correcting lower limb deformity to improve gait, a randomised controlled trial against surgery based on clinical assessment alone and against natural history would be necessary and follow-up should extend into adulthood. The difficulties of organising a trial of this scale are self-evident.

Well designed surgical trials are necessary in the field of CP. Scientific rigour similar to the one that led to the improvements in gait analysis would be necessary in designing trials. However, a pragmatic approach is also necessary as ethical considerations, practical difficulties and recruitment problems represent significant challenges. Support from professional bodies and patient/family groups can help put forward the need for such studies to the relevant funding bodies and drive this area of research forward.

15:00 - 15:30	**COFFEE IN THE EXHIBITION HALL**
15.30 - 17.00	**SESSION 3a (A2)** **Cerebral Palsy Descriptive** **Chairmen: Malgorzata Syczewska, Elke Viehweger**
O14 Klum, Elisa	Predictors of excessive frontal plane trunk lean in adolescents with cerebral palsy
O15 Bonikowski, Marcin	Static proximal muscle shortening is present already in very young children with spastic bilateral CP
O16 Meyns, Pieter	Neural control mechanism of forward and backward walking is preserved in children with Cerebral Palsy
O17 Gómez, David	Relationship among gillette gait index parameters and GMFCS
O18 Löwing, Kristina	Exploring relationships of the Gait Deviation Index and measures of body functions and activity in children with cerebral palsy, by using ICF as a framework
O19 Svehlik, Martin	The growth and the development of gastro-soleus contracture in cerebral palsy
O20 Darras, Nikolaos	Antagonist muscle strength development, of the lower extremities of ambulatory children with bilateral spastic cerebral palsy, in comparison to typically developing controls.

O21 Riad, Jacques	Muscle strength and muscle volume in unilateral Cerebral Palsy
O22 Riad, Jacques	Does muscle strength influence gait performance in unilateral Cerebral Palsy?
15.30-17.00	**SESSION 3b (C4)** **Technical and Simulation** **Chairmen: Ilse Jonkers, Michael Schwartz**
O23 Desaily, Eric	Simulation of Muscle contracture in Cerebral Palsy (SiMusCP). Validation of a decision support system for hamstrings lengthening
O24 Kosterina, Natalia	Force enhancement and force depression in a modified muscle model used for muscle activation prediction
O25 Wang, Ruoli	Compensatory strategies for excessive muscle co-contraction at the ankle
O26 van der Krogt, Marjolein	A model of muscle spasticity in OpenSIM
O27 Rozumalski, Adam	Strictly Enforcing the Rigid Body Constraint Improves the Performance of a Functional Model Calibration Method: Results from a Mechanical Analog of the Leg
O28 Passmore, Elyse	Improving repeatability of setting volume origin and coordinate system for 3D gait analysis

O29 Gantelius, Stefan	Volumetric motion analysis - a simple and accurate way of measuring 3 dimensional reach in children
O30 Sangeux, Morgan	Expert assessment of conventional and functional techniques to determine the knee axis
O31 van Hutten, Kim	A tablet computer “app” for neuromusculoskeletal physical examination in children with cerebral palsy

O14

PREDICTORS OF EXCESSIVE FRONTAL PLANE TRUNK LEAN IN ADOLESCENTS WITH CEREBRAL PALSY

Elisa Klum[1], Harald Böhm[1], Verena Fenner[2], Matthias Hösl[1] and Leonhard Döderlein[1]

[1]Behandlungszentrum Aschau GmbH, Orthopaedic Hospital for Children , Aschau im Chiemgau, Germany
[2] Eastern Switzerland Childrens' Hospital, Laboratory of Motion Analysis, St. Gallen, Switzerland

INTRODUCTION

Adolescents with cerebral palsy often complain about their excessive trunk lean in the frontal plane during walking, mainly because they are concerned about their physical appearance among their peers. However excessive trunk lean might assist foot clearance to compensate for contractures and muscle weakness of the legs [1]. In particular weakness, secondary to surgical muscle tendon lengthening in childhood might predispose patients to greater compensatory movements of the trunk. Therefore the aim was to calculate predictors for increased thorax obliquity on adolescents with cerebral palsy with and without previous muscle tendon lengthening.

PATIENTS/MATERIALS and METHODS

51 patients with diplegia, GMFCS II, between 12 and 21 years participated. 22 patients had any previous surgeries (CP). 29 patients had previous calf, hamstrings and adductor muscle lengthening surgeries (CPS). 15 typically developed adolescents served as controls (TD). All participants walked barefoot without assistive devices. Gait was analysed with a Vicon camera system, followed by a manual clinical examination. ANOVA on patient groups (CP, CPS, TD) was performed on thorax obliquity range (TOR). In addition stepwise multiple linear regressions of the response value TOR were performed on the predictive terms from gait analysis and separately for clinical data. Predictors were typical parameters associated with reduced foot clearance [1].

RESULTS

TOR was 4±3°, 15±8° and 17±8°, for TD, CPS and CP adolescents respectively. CP and CPS showed significant differences in TOR between TD (both $p<.001$), but not between CP and CPS ($p=.36$). Best clinical predictors in CP patients were ankle dorsiflexion, ankle dorsiflexion strength and passive knee flexion, together explaining 60 % of the variance in TOR. In CPS patients it was only passive knee flexion explaining 31 % of the variance in TOR. Gait analysis revealed any predictors for CPS and reduced ankle dorsiflexion in swing as the best predictor (40 %) for CP.

DISCUSSION & CONCLUSIONS

The hypothesis that previous muscle-tendon lengthening increased trunk lean could not be confirmed in this study. Reduced passive knee flexion was a good predictor of TOR in both patients groups. In addition patients without surgical tendon lengthening showed a correlation of TOR with ankle contractures and weakness of dorsiflexors, which was confirmed by gait analysis. This was not a predictor in CPS, since calf muscle lengthening procedures might have corrected equinus contractures. In conclusion treatment of excessive frontal plane trunk lean should first focus on increasing passive knee flexion and secondly to reduce foot drop in swing by the help of orthoses or management of equinus contractures.

REFERENCES

[1] Perry J. (1992) *Gait Analysis*: pp 265-279

O15

STATIC PROXIMAL MUSCLE SHORTENING IS PRESENT ALREADY IN VERY YOUNG CHILDREN WITH SPASTIC BILATERAL CP.

Marcin Bonikowski[1], Anna Czernuszenko[2], Jakub Gąsior[3] and Mariusz Pawłowski[2]

[1]Mazovian Neurorehabilitation and Psychiatry Center, Rehab. Department, Movement Analysis Lab., Zagórze n. Warsaw,, Poland
[2]Mazovian Neurorehabilitation and Psychiatry Center, Rehab. Department, Zagórze n. Warsaw,, Poland
[3]Warsaw Medical University, Warsaw, Poland

INTRODUCTION

Muscle shortening secondary to spasticity develops in time in children with spastic CP.

Aim: To manually examine muscle length in lower extremities in the youngest children with bilateral spastic CP

PATIENTS/MATERIALS and METHODS

We analysed passive range of motion (PROM) in lower extremities in a serie of 100 consecutive children with spastic diplegia younger than 3 years selected for spasticity treatment with Botulinum Toxin. The results of the group have been pooled and presented as means.

RESULTS

In the study group there were 58 boys and 42 girls in a mean age of 2,39 (SD±0,57) years. The GMFCS distribution was 8% GMFCS level I, 23% - GMFCS II, 29% - GMFCS III, 28% - GMFCS IV and 12% - GMFCS V. 21 children were walking independently, 54 were walking with support of parents, 25 were not able to walk even with major support.

The mean (SD) PROM values in the study group were as follows:

Hip extension in supine position: -15,5 (10,5)

Hip abduction in flexion: 47,8 (17,2)

Hip abduction in extension: 30,3 (12,3)

Popliteal angle: 50,1 (23)

Knee flexion in prone position: 97,9 (26)

Ankle dorsiflexion with knee flexed: 17,1 (12,8)

Ankle dorsiflexion with knee extended: 4,82 (10,2).

Muscle shortening was more pronounced in nonambulators. Differences in PROM hip extension in supine position, hip abduction in flexion and extension and knee flexion in prone position between ambulators vs. nonambulators reached statistical significance.

DISCUSSION & CONCLUSIONS

Our data show that muscle shortening is present already in very young children with spastic CP. It is especially prominent in proximal muscles: hip flexors, hamstrings and rectus femoris. Early development of structural changes might indicate the need for reconsideration of therapeutic strategies in the group of very young children with bilateral CP

REFERENCES

O16

NEURAL CONTROL MECHANISM OF FORWARD AND BACKWARD WALKING IS PRESERVED IN CHILDREN WITH CEREBRAL PALSY

Pieter Meyns[1], Guy Molenaers[2], Kaat Desloovere[3], Leen Van Gestel[3] and Jacques Duysens[1]

[1]KU Leuven, Kinesiology, Leuven, Belgium
[2]UZ Leuven, Clinical Motion Analysis Laboratory, Leuven, Belgium
[3]KU Leuven, Rehabilitation Sciences, Leuven, Belgium

INTRODUCTION

Forward (FW) and backward gait (BW) have been the subject of a vast amount of studies in the past, due to the notion that a simple reversal of the neural mechanism for FW could lead to BW [1]. This notion was based upon experiments on animals [2], and led to the suggestion that basic neural control structures can simply reverse the automatism of FW to drive BW in cats and humans [3]. In humans, previous studies examined leg movements comparing EMG and kinematics of FW and time-reversed BW. However, recent evidence points out that arm swing during gait might also be controlled by spinal automatisms [4]. Therefore the question arises whether arm swing in BW is also reverse of FW [5]. In addition, the question arises to what extent the cortex contributes to this type of interlimb coordination. In most children with Cerebral Palsy (CP) there is cortical damage. Hence if the FW-BW reversal is fully preserved this would argue in favor of subcortical structures being the prime generators of interlimb coordination during gait.

PATIENTS/MATERIALS and METHODS

26 spastic CP (4-12 yr) and 24 control (5-12 yr) subjects were included. CP included 11 children with hemiplegia (HE) and 15 with diplegia (DI). Total body kinematics were recorded with an 8 camera Vicon system. 3 trials were assessed for two walking directions (FW and BW). Angular displacement of the upper arm (UA), lower arm (LA), upper leg (UL), lower leg (LL), and foot (FO) were measured with respect to the vertical (elevation angle) in the sagittal plane. The time normalized elevation angle traces of BW were reversed in time (revBW) and correlated to the FW traces.

RESULTS

Correlations between the mean traces of FW and revBW for all segments of each group are presented in table 1. In both TD and CP groups, the arms moved diagonally with respect to the legs during BW. Very strong correlations between FW and revBW were evident for both the upper and lower limbs in all three groups. Despite movement impairment of the limbs in CP, correlations between FW and revBW traces were similar for the least and most affected sides. In DI correlations between FW and revBW of the foot segment appeared lower compared to the other groups. However, they were still highly significant.

Table 1 Correlations between the mean traces of FW and revBW

	TD	DI	HE
Least affected Upper leg	0.983	0.953	0.963
Least affected lower leg	0.988	0.938	0.969
Least affected foot	0.981	0.788	0.924
Most affected upper leg	0.983	0.993	0.986
Most affected lower leg	0.992	0.960	0.985
Most affected foot	0.986	0.870	0.965

DISCUSSION & CONCLUSIONS

A high degree of similarity between the limb kinematics of FW and revBW is apparent in persons with CP. This means that the simple reversal mechanism of FW that leads to BW, may still be preserved in persons with a cortical deficit. The current results thus provide further indirect evidence that interlimb coordination during gait depends on coupling between spinal CPGs and that this does not depend primarily on corticospinal projections.

REFERENCES

[1] Thorstensson (1986) Exp Brain Res, 61(3): 664-668. [2] Grillner (1981) Handbook of Physiology, Section 1: The nervous system II Motor Control, 1179-1236. [3] Duysens et al. (1996) J Neurophysiol. 76(1): 301-310. [4] Dietz (2002) Trends Neurosci, 25(9): 462-467. [5] Zehr and Duysens (2004) Neuroscientist, 10(4): 347-361.

O17

RELATIONSHIP AMONG GILLETTE GAIT INDEX PARAMETERS AND GMFCS

David Gómez Andrés[1], Irene Pulido Valdeolivas[1], Juan Andrés Martín[2], Javier López[3] and Estrella Rausell Tamayo[1]

[1]Trastornos del Desarrollo y Maduración Neurológica. IdiPaz. Universidad Autónoma de Madrid.
[2]E.U. Fisioterapia ONCE-UAM. Universidad Autónoma de Madrid.
[3]Hospital Universitario Infanta Sofía, Rehabilitación, S.S. de los Reyes (Madrid)

INTRODUCTION

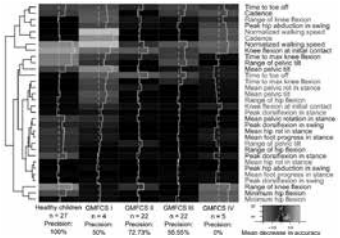
Gait indices are usually defined using unsupervised strategies in order to represent gait deviation from a reference dataset. However, when gait disability is treated, the objective is not a complete normalization of gait but an increase in functionality. The aim of this study is to relate GMFCS, as a representation of disability in cerebral palsy (CP), with Gillette Gait Index (GGI) parameters.

PATIENTS/MATERIALS and METHODS

27 healthy school-aged children and 56 children with bilateral spastic CP and predominant affection of lower limbs (GMFCS I: 4 II: 22 III: 22 IV: 5 children) were recruited. The 16 left and the 16 right kinematic parameters used to calculate GGI were measured in each child and a mean of 4-5 cycles was obtained for each parameter. Spearman's rho and its confidence interval were calculated in order to assess correlation among GMFCS and each parameter variable. Random forests were trained by using GMFCS as dependent variable and gait parameters as independent variables. Goodness of fit was estimated by precision (1 - OOB rate of errors) and influence of each dependent variable was estimated by mean percentage of decrease in model accuracy when variable is out the bag (both for the whole model and for each category).

RESULTS

Only 9 out 32 gait parameters show a significant correlation with GMFCS. Some of random forest results are expressed in the following heatmap. Importance for classification performance in each category of a particular gait parameter (right in red and left in green) is expressed in the corresponding interaction. The greener the square is, the more important the gait parameter is distinguishing that class from the other ones. The resultant predictive model discriminates healthy children from disabled ones really well. Model performance was more modest when distinction among GMFCS states in CP children. Different sets of variables are involved in each class.



DISCUSSION & CONCLUSIONS

GGI parameters may be a good selection to express gait deviation from normality in children with CP. However, only some of these parameters may represent accurately gait changes that lead to an increase in dependency. Moreover, importances of these parameters changes depend on functionality stage. Similar results are likely to be found in indices based on unsupervised learning strategies.

REFERENCES

[1] Gray L et al. The gross motor function classification system: an update on impact and clinical utility. Pediatr Phys Ther 2010. 22(3):315-20. [2] Liaw A et al. Classification and regression by random Forest. R News 2003; 2/3. [3] Schutte et al. An index for quantifying deviations from normal gait. Gait & Posture 2000;11:25–31

O18

EXPLORING RELATIONSHIPS OF THE GAIT DEVIATION INDEX AND MEASURES OF BODY FUNCTIONS AND ACTIVITY IN CHILDREN WITH CEREBRAL PALSY, BY USING ICF AS A FRAMEWORK

Kristina Löwing[1], Karin Thews[1], Yvonne Haglund[2] and Lanie Gutierrez Farewik[3]

[1]Karolinska Institutet, Dept of Women's and Children's Health, Stockholm, Sweden
[2]Karolinska Institutet, Dept of Women's and Children's Health, Stockholm , Sweden
[3]Royal Institute of Technology, Karolinska Institutet, Dept of Women's and Children's Health, Stockholm, Sweden

INTRODUCTION

The Gait Deviation Index (GDI) offers a possibility to summarize several gait parameters from three dimensional (3D) gait analysis into a multivariate measure of overall gait pathology (1). The GDI can be used to follow children's gait during development but also to evaluate specific interventions. Associations between body functions and activities within the ICF framework are often assumed to demonstrate a linear relationship, an assumption which today has been questioned, but still not clearly elucidated. The aim of the study was to explore relationships between GDI and other measures of body functions and activities in children with cerebral palsy (CP) before and three month after treatment with botulinumtoxin-A (BoNT-A) and goal-directed, activity-focused training (GDT).

PATIENTS/MATERIALS and METHODS

A consecutive sample of 40 children, age 4-12 years, with spastic unilateral or bilateral CP, GMFCS I and II, referred to treatment with BoNT-A, participated. The children were examined before and three months after treatment. Assessments included 3D gait analyses with gait data transformed to GDI, range of motion (ROM), spasticity scoring, selective muscle control of the ankle (SMC) (2). Furthermore all children choose an activity goal which was graded using goal attainment scaling (GAS) and they were practicing towrds their goals in the everyday environment.

RESULTS

At baseline assessment the GDI and SMC demonstrated a relationship, showing children with the most favourable gait score having the best voluntary muscle control of their ankle (r=0.39). A relation was also observed between the distribution of CP and GDI (r=-0.40), demonstrating children with unilateral CP having the higher GDI. After three months a correlation was observed between improvement in GDI and high goal attainment (r=0.35). Furthermore at the follow-up also other relationships were observed. The reduced spasticity in the ankle correlated to improved ankle dorsiflexion (r=-0.55).

DISCUSSION & CONCLUSIONS

The GDI seemed to capture important gait characteristics in children with CP and also demonstrated a relationship towards the ability to voluntary control the muscle in the ankle. At the follow-up the children with improvement in gait seemed to also have reached their activity goals to a rather high extent.

REFERENCES

1. Schwartz MH, Rozumalski A. The Gait Deviation Index: a new comprehensive index of gait pathology. Gait Posture 2008;28:351-7

2. Boyd RN, Graham HK. Objective measurement of clinical findings in the use of botulinum toxin type A for the management of children with cerebral palsy. Eur J Neurol 1999;6:23-5

O19

THE GROWTH AND THE DEVELOPMENT OF GASTRO-SOLEUS CONTRACTURE IN CEREBRAL PALSY

Martin Švehlík[1], Lutz Leistritz[2], Tanja Kraus[1], Ernst B Zwick[1], Gerhard Steinwender[1] and Wolfgang E Linhart[1]

[1]Medical University of Graz, Peadiatric Orthopaedic Unit, Department of Paediatric Surgery, Austria
[2]Institute of Medical Statistics, Jena University Hospital, Computer Sciences and Documentation, Germany

INTRODUCTION

The development of contractures in children with spastic cerebral palsy is an important clinical as well as scientific issue. A common model for the development of contractures suggests that increased muscle tone shortens muscles, which leads to reduced growth of sarcomeres and tighter non-contractile muscle and tendon tissue. However, the spasticity is not the only factor influencing the contracture development. Based on our clinical observation we hypothesize that the body growth might play a key role in development of gastrocnemius contracture.

PATIENTS/MATERIALS and METHODS

We performed a retrospective cross-sectional analysis of 3D gait data of 244 children (385 legs) with spastic diplegic CP and equinus gait. Children were subdivided according to age into 6 subgroups (5-6, 7-8, 9-10, 11-12, 13-14 and 15-18 years) to show the changes during the whole period of growth. The height of all the participants at each visit was recorded. A formerly trained Generalized Dynamic Neuronal Network (GDNN) [1], a reliable method of automatic gait pattern recognition and classification, was used to discriminate between dynamic and fixed contracture of gastro-soleus muscle based on the ankle and knee kinematics and moments. The Spearman correlation coefficient was used to show the relationship between the growth and gastro-soleus contracture development.

RESULTS

The relative increase of fixed contracture of the gastro-soleus muscle between the age groups correlates positively with the relative increase in height ($r=0.9$; $p<0.05$). Therefore, the development of equinus contracture is tightly correlated with growth velocity in children with diplegic spastic CP.

DISCUSSION & CONCLUSIONS

The range of ankle motion is decreasing during childhood [2]. It might sound contradictory but the spasticity of gastro-soleus muscle is decreasing between the ages of 6 to 12 [3] as well . It seems that contracture development is not only moderated by spasticity and the reduction in tone does not prevent the development of contractures in CP [4]. We proved that the development of equinus contracture is tightly correlated with growth velocity in CP. Therefore we would like to stress the growth spurt as an important period for contracture development as well as prevention.

REFERENCES

1. Zwick, E.B., et al., *Classification of equinus in ambulatory children with cerebral palsy-discrimination between dynamic tightness and fixed contracture.* G&P, 2004. **20**(3): p. 273-9.
2. Nordmark, E., et al., *Development of lower limb range of motion from early childhood to adolescence in cerebral palsy: a population-based study.* BMC Med, 2009. **7**: p. 65.
3. Hagglund, G. and P. Wagner, *Development of spasticity with age in a total population of children with cerebral palsy.* BMC Musculoskelet Disord, 2008. **9**: p. 150.
4. Tedroff, K., et al., *Long-term effects of botulinum toxin A in children with cerebral palsy.* Dev Med Child Neurol, 2009. **51**(2): p. 120-7.

Acknowledgement: Martin Švehlík is a recipient of an APART-fellowship of the Austrian Academy of Sciences at the Gaitlaboratory, Department of Paediatric Orthopaedics, Medical University of Graz.

O20

ANTAGONIST MUSCLE STRENGTH DEVELOPMENT, OF THE LOWER EXTREMITIES OF AMBULATORY CHILDREN WITH BILATERAL SPASTIC CEREBRAL PALSY, IN COMPARISON TO TYPICALLY DEVELOPING CONTROLS.

Nikolaos Darras[1], Dimitris Pasparakis[2], Magda Tziomaki[1], Christos Nestoridis[1], Manoussos Pentarakis[1] and Antigoni Papavasiliou[3]

[1]ELEPAP, Gait & Motion Analysis Center, Athens, Greece
[2]"Aglaia Kyriakou" Children's Hospital, 2nd Orthopaedic Dept, Athens, Greece
[3]Penteli Children's Hospital, Neurological Dept, Athens, Greece

INTRODUCTION

Muscle weakness is a major component of cerebral palsy (CP) that contributes to functional disability[1,2]. Understanding the development of muscle strength in patients of different involvement and age group is important, in order address objectively the aims of the treatment. The goal of this study was to compare the pattern of changes of antagonist muscle goups in muscle strength between ambulatory patients with bilateral spastic CP and Typically Developing subjects between the ages of 7 and 16 years.

PATIENTS/MATERIALS and METHODS

86 Typically Developing subjects (TD), 89 diplegic (DIPL) and 53 quadriplegic ambulatory (QUAD) patients with CP. In order to study the development of force in different ages, the subjects were divided in five age groups from age 7-16 with a two years interval. TD controls were volunteers attending a private school close to our laboratory. The patients with CP were selected from patients referred to our center for gait analysis. All subjects had 3 measurements of 7 muscle groups, the hip adductors and abductors, hip extensors and flexors, knee extensors and flexors and ankle dorsiflexors. The force data measurements were collected using a Hoggan Microfet 2 digital hand held dynamometer always from the same examiner. Two methods of analysis of the force data were employed: A) Absolute Force (AF), using the averaged raw data collected from the dynamometer expressed in lbs and B) Normalized Force (NF), using normalized force data values in order to account for body weight differences. Descriptive statistical analysis and ANOVAs were used to study differences among all Categories and Age Groups.

RESULTS

The arrangement of the force graphs enabled the identification of the pattern of force development of the pairs of antagonist muscles measured. In most of the NF diagrams, an almost parallel force development was observed; however, an imbalance in the NF values between the values of hip adductors and abductors was clearly identifiable. This imbalance is related to the fact that hip adductors in children with CP were exhibiting values close to TD, while hip abductors were exhibiting significantly lower values across all age groups. A similar pattern was identified between hip extensors and hip flexors. CP hip extensor values were not found significantly different from TD values while hip flexor values were found significantly lower in CP than in TD subjects. A different pattern was identified for the knee muscle groups, where both muscle group forces (extensors & flexors) were found significantly reduced compared to TD values. There is tendency though for the knee extensors to maintain force while knee flexors' force decreases with increasing age.

DISCUSSION & CONCLUSIONS

In CP, a constant pattern of significant muscle strength imbalance between antagonist muscles across all ages was identified. Hip abductors, hip flexors and knee flexors were found significantly weaker than adductors and extensors. Since this is a cross-sectional study, this indicates that the muscle strength imbalance in CP, is present from the early ages and is not changing significantly during development.

REFERENCES

1. Thompson N et al. (2010) Muscle strength and walking ability in Diplegic Cerebral Palsy: Implications for assessment and management. Gait & Posture 2. Shortland A. (2011) Strength, Gait and Function in Cerebral Palsy. Gait & Posture 33: 319-320.

O21

MUSCLE STRENGTH AND MUSCLE VOLUME IN UNILATERAL CEREBRAL PALSY

Jacques Riad[1] and Eva W Broström[2]

[1]Skaraborg Hospital, Orthopedic Department, Skövde, Sweden
[2]Karolinska Institute, Motion Analysis Laboratory, Stockholm, Sweden

INTRODUCTION

Muscle weakness is common in cerebral palsy (CP) and strength training, sometimes associated with increased muscle volume, may improve function. However the results are equivocal and reported mainly in spastic diplegic CP. In unilateral CP the involved limb is always smaller, even in independent ambulators (1). Differences in muscle strength and possible influence of muscle volume are not known in this high functional group.

PATIENTS/MATERIALS and METHODS

In 44 patients with unilateral CP, mean age 17,5 years (range 13,0-24,0 years) and 23 matched healthy controls muscle strength was measured. Twenty-one was female and 23 males, all GMFCS I. Of the 44 patients, 30 had muscle volume measurements performed. A validated strength measuring chair was used and maximal voluntary isometric contraction (MVIC) was obtained (2). Axial magnetic resonance images were collected from the lower limb and muscle volumes calculated from cross-sectional area considering slice thickness and gaps.

RESULTS

Knee extensor strength was on the involved side 1,56 (Nm/kg body weight), compared to 2,4 in the control group ($p<0,001$). Plantar flexor strength was 1,29 compared to 2,30 Nm/kg ($p=<0,001$) and dorsi flexors 0,18 compared to 0,47 Nm/kg ($p<0,001$). On the non-involved side knee extensors and plantar flexors were decreased in strength, ($p=0,036$ and $p= 0,034$ respectively), compare to the control group. Dorsi flexors showed no difference to the control group. Within the patient group there were significant differences ($p<0,001$) comparing the involved side with the non-involved in all muscle groups. Muscle volumes were decreased in all muscle groups ($p<0,001$) comparing involved with non-involved side.

Muscle strength correlated with muscle volume, ($p=0,05$), on the involved and non-involved sides in dorsi flexors (correlation coefficient =0,489 and 0,496 respectively) and on the involved side in plantar flexors (correlation coefficient=0,468). There was no correlation in knee extensors on either side and no correlation on the non-involved side in plantar flexors.

DISCUSSION & CONCLUSIONS

In unilateral CP there is clear decrease in strength and muscle volume, in knee extensors, plantar flexors and dorsi flexors. The correlation between muscle strength and muscle volume is most pronounced in the ankle joint. McNee reported in 13 ambulant children with spastic CP an increase in muscle volume and strength after plantar flexor strengthening training (3). Nyström Eek also reported on children with spastic diplegic CP, and found muscle weakness most pronounced in the ankle (4). However these two studies included diplegic CP and overall more severely involved patients.

In this study we conclude that there is an association between muscle strength and muscle volume although not in all muscle groups measured. Most probably other variables than knee and ankle muscle strength measured as MVIC and muscle volumes play a major role for function in unilateral CP. However the functional gain including walking ability has not been addressed in this study and further studies are needed.

REFERENCES

[1] Riad J. Are muscle volume differences related to concentric muscle work during walking in hemiplegic cerebral palsy. 2012. [2] Örtqvist M. Reliability of a new instrument for measuring plantarflexor muscle strength. 2007. [3] McNee AE. Increases in muscle volume after plantarflexor strength training in children with spastic cerebral palsy. 2009. [4] Nyström Eek M. Walking ability is related to muscle strength in children with cerebral palsy. 2008.

DOES MUSCLE STRENGTH INFLUENCE GAIT PERFORMANCE IN UNILATERAL CEREBRAL PALSY?

Jacques Riad[1] and Eva W Broström[2]

[1]Skaraborg Hospital, Orthopedic Department, Skövde, Sweden
[2]Karolinska Institute, Motion Analysis Laboratory, Stockholm, Sweden

INTRODUCTION

Muscle weakness is common in cerebral palsy (CP) and one of the symptoms of the motor impairment. Muscle strength has been reported to correlate with gait performance, but mainly in diplegic cerebral palsy patients using the GMFCS as outcome for walking ability (1, 2). In unilateral cerebral palsy patients often have a limited impairment and are independent ambulators (GMFCS I and II), despite decreased muscle strength and pronounced difference in muscle volume with obvious deviations in movement pattern. Deterioration in walking and overuse in adulthood in CP has however been reported (3). The goal was to study the relationship between muscle strength and muscle work performed during walking and possible relationship between muscle strength and gait performance.

PATIENTS/MATERIALS and METHODS

In 44 patients with unilateral CP and 23 matched healthy controls muscle strength was assessed. Patient's mean age was 17,5 years (13,0-24,0 years), 21 females and 23 males, all GMFCS I. A validated strength measuring chair was used and maximal voluntary isometric contraction (MVIC) (Nm/kg) obtained (4). Three dimensional gait analysis with an 8 camera system and 2 force plates was used to calculate maximal moments (Nm/kg) and muscle work (Joule/kg) during walking. In addition temporal spatial data was obtained, as measure of gait performance.

RESULTS

There was no significant correlation between muscle strength and concentric or eccentric muscle work performed during walking in knee extensors, plantar flexors and dorsi flexors on the involved and non-involved side. When calculating the percentage of muscle strength used in relation to maximal muscle strength available plantar flexors on the involved side were used 102%, dorsi flexors 41% and knee extensors 28 %. On the non-involved side 78%, 44% and 38% respectively. The corresponding numbers in the control group were 66%, 48% and 33%. There was a moderate correlation (r=-0,479) between knee extensor muscle strength and double support time on the involved side.

DISCUSSION & CONCLUSIONS

We found that muscle strength does not seem to correlate with muscle work performed during walking, although plantar flexors on the involved side are used just over 100% of the maximum voluntary strength. The markedly increased use of plantar flexor muscles could in long term have implications and to some extent explain reported deterioration in walking and signs of fatigue and overuse in adulthood (3). From a gait performance perspective muscle strength has no major influence in this mildly involved and high functioning group as opposed to more severely involved children with a different CP pattern (1, 2). We conclude that muscle strengthening of the knee and ankle muscles would most likely not be beneficial in this patient group. However, a previous study found decreased concentric muscle work during walking from plantar flexors on both the involved and non-involved side in unilateral CP, with increased muscle work from hip extensors bilaterally (5). We speculate that strengthening of the hip extensor muscles could result in improved gait performance.

REFERENCES

1 McNee AE. Increases in muscle volume after plantarflexor strength training 2009.
2 Nyström Eek Walking ability is related to mm strength in children with cerebral palsy 2008.
3 Opheim A. Walking function, pain, and fatigue in adults with cerebral palsy: 2009.
4 Örtqvist M. Reliability of a new instrument for measuring plantarflex musclestrength.2007.
5 Riad J. Power generation in children with spastic hemiplegic cerebral palsy. 2008.

O23

SIMULATION OF MUSCLE CONTRACTURE IN CEREBRAL PALSY (SIMUSCP). VALIDATION OF A DECISION SUPPORT SYSTEM FOR HAMSTRINGS LENGTHENING

Eric Desailly[1], Abdennour Sebsadji[1], Daniel Yepremian[1], Farid Hareb[1], Néjib Khouri[2, 1]

[1]Fondation Ellen Poidatz, Motion Analysis Unit, St Fargeau Ponthierry, France
[2]Armand Trousseau Hospital, Department of Pediatric Orthopaedic Surgery, Paris, France

INTRODUCTION

Musculoskeletal modeling associated with gait analysis help to exclude indication of a hamstrings lengthening (HL) by the objectification of a non-functional impact of a supposed muscular contracture [1]. It does not allow a positive diagnosis of the indication of HL. That's why we developed a customizable musculoskeletal model able to analyze the muscles kinematics during walking and to simulate the maximum muscle length from clinical goniometric measurements (SiMusCP). This connection introduces a new diagnostic approach, theoretically exhaustive, of the possible causality of hamstrings contracture on CP children gait impairments. The purpose of this study is to evaluate the real contribution of this procedure to the therapeutic decision.

PATIENTS/MATERIALS and METHODS

42 cerebral palsy children (12±3 years) were divided into two groups: 31 (G1= 60 lower limbs) and 11 (G2= 20 lower limbs), respectively having followed and not-followed HL among all the associated surgeries. All patients had clinical gait analysis before and 1.9±0.8 years after surgery. The lower limbs were classified, improved or not improved by HL, with a validated supervised classification system (linear SVM). SiMusCP procedure is performed retrospectively on the basis of clinical data and preoperative gait analysis. Maximum functional hamstrings lengths were computed during gait. A specific musculoskeletal model was used at this purpose [2] and to realize direct kinematics simulations of the hamstrings maximum clinical lengths corresponding to the angles measured by experimented physicians testing the modified popliteal angles of the patients. HL should not have been realized if hamstrings maximum functional length or hamstrings maximum clinical length were short but only when both were short. The concordance between the predictions from the simulation and the actual outcome of the surgery was evaluated.

RESULTS

The optimal clinical and functional thresholds were respectively identified by ROC curves as healthy subjects' mean hamstrings maximum walking length +0.85 SD and –0.6 SD. SiMusCP procedure had a sensitivity of 87.5% and a specificity of 65%. The positive predictive value was 83.3%. The intensity of the connection between the result of surgery and the indication produced by SiMusCP were significantly ($p < 0.001$) very high (Coefficient of Yule $Q = 0.86$)

DISCUSSION & CONCLUSIONS

SiMusCP requires significant rigor in the collection of data (morphological, clinical, or from the CGA) used as input. This decision support system can improve HL results by making outcomes more predictable.

REFERENCES

[1] Arnold A. S. et al. Gait & posture, 23(3), 273–281.
[2] Desailly, E. et al. Journal of Biomechanics, 43(13), 2601–2607.

O24

FORCE ENHANCEMENT AND FORCE DEPRESSION IN A MODIFIED MUSCLE MODEL USED FOR MUSCLE ACTIVATION PREDICTION

Natalia Kosterina[1], Ruoli Wang[1], Anders Eriksson[1] and Elena M. Gutierrez-Farewik[1]

[1]KTH, Mechanics, Stockholm, Sweden

INTRODUCTION

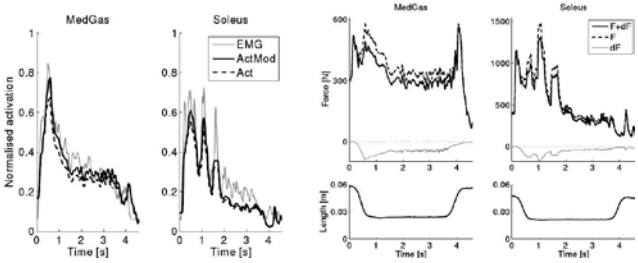
Force depression and force enhancement induced by active muscle shortening and lengthening, respectively, represent muscle history effects. The objective of the study was to apply the history effect in a musculoskeletal model used for dynamic movements simulation. Due to the limitations in measuring muscular force in vivo and relying on motor control feature to prevent unexpected force changes, the muscle history was introduced in evaluated muscle activation.

PATIENTS/MATERIALS and METHODS

A muscle model depending on the preceding contractile events together with the current parameters was developed for OpenSim software using as a basis the activation patterns obtained from the software, with its common implicit activation-force expressions. An improved muscle model was applied in dynamic simulations of heel-raise in upright position and squat movements. Muscle activations were computed using joint kinematics and ground reaction forces recorded from the motion capture of seven individuals. In the muscle-actuated simulations, a modification was applied to the computed activation, and was compared to the measured electromyography data.

RESULTS

The modified activation was closer to experimentally observed activation in 3 out of 4 studied muscles. If the modification applied to muscular force, the history gives a small but visible effect for the squat and heel-raise. The modification is more significant for simulations of fast movements with a load.



DISCUSSION & CONCLUSIONS

A skeletal muscle model was enhanced by a history phenomena using a simple formula [1,2]. The history modification improves the existing muscle model and gives more accurate description of underlying activations in musculoskeletal system movement simulation. Though current techniques do not enable us to validate the result fully, the supplement improved description of skeletal muscle force and showed the importance of the modification in demanding tasks.

REFERENCES

[1] Kosterina, N., Westerblad, H., Eriksson, A., 2009. Mechanical work as predictor of force enhancement and force depression. Journal of Biomechanics 42(11), 1628–1634.

[2] Kosterina, N., Westerblad, H., Eriksson, A., 2011. History effect and timing of force production introduced in a skeletal muscle model. Biomechanics and Modeling in Mechanobiology.DOI: 10.1007/s10237-011-0364-5.

COMPENSATORY STRATEGIES FOR EXCESSIVE MUSCLE CO-CONTRACTION AT THE ANKLE

Ruoli Wang[1], Elena M Gutierrez-Farewik[1, 2]

[1]Royal Institute of Technology, Department of Mechanics, Stockholm, Sweden
[2]Karolinska Institutet, Department of Women's and Children's Health, Stockholm, Sweden

INTRODUCTION

Co-contraction is the concurrent activation of agonist and antagonist muscles (antagonistic pairs) across the same joint. In some gait disorders, e.g. spastic gait, the temporal separation and magnitude differences of activities between agonist & antagonist muscles are frequently attenuated and motor control becomes poor. The aim of this study was to identify the necessary compensatory mechanisms to overcome excessive co-contraction of the soleus - tibialis anterior pair using induced acceleration analysis (IAA) to retain a normal walking pattern.

PATIENTS/MATERIALS and METHODS

Nine healthy adults (age: 30 ± 3yrs) were examined using a motion capture system (Vicon MX40). Ground reaction forces were obtained from two forceplates (Kistler). Surface EMG signals (Motion Laboratory System) were recorded from the biceps femoris long head (BFLH), rectus femoris (RF), medial gastrocnemius (GAS), soleus (SOL), and tibialis anterior (TA) bilaterally. The simulations were performed in OpenSim, which consisted of scaling, inverse kinematics, residual reduction algorithm (RRA) and computed muscle control (CMC) [1]. IAA was used to compute contributions of primary ankle dorsif/plantarflexors and knee flexor/extensors to the accelerations of ankle and knee joints. The agonist and antagonistic muscles can be identified by defining the one with lesser activation as antagonist [2]. Three co-contraction levels (normal, medium and high) were simulated by increasing the activation of the antagonist muscle. The response of other muscles to the excessive co-contraction of SOL-TA was computed by repeating CMC and IAA after constraining excitations of SOL-TA at each co-contraction level.

RESULTS

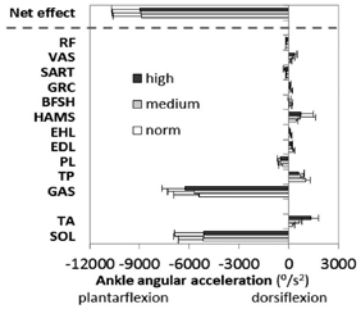


Figure 1. The contributions from primary ankle and knee muscles to the ankle joint in the 2nd sub-phase (SOL: agonist) were illustrated (VAS: vastus medialis, SART: sartorius, GRC: gracilis; BFSH: biceps femoris short head; HAMS: semimemberanosus, semitendinosus and BFLH; EHL: extensor halluces longus; EDL: extensor digitorum longus; PL: peroneus longus; TP: tibialis posterior). When SOL-TA co-contraction is increased through increased excitation of TA, TA can contribute more to decelerate ankle plantarflexion. The primary compensation is increased excitation of GAS, which increases ankle plantarflexion acceleration and knee extension deceleration. At the knee joint, SART can also increase its extension deceleration contribution as compensation.

DISCUSSION & CONCLUSIONS

Results of the simulation indicated that with a high level of the SOL-TA co-contraction, one can still perform normal walking through other means. When increased co-contraction was simulated in the SOL-TA by increasing excitation of TA in the 2nd sub-phase, GAS was the largest compensator at the ankle and knee. In addition, the net joint accelerations from the ankle and knee muscles were generally unchanged, which indicated that the ankle and knee muscles alone are able to compensate for increased co-contraction at the ankle joint.

REFERENCES

[1] Delp, S.L. et.al (2007) IEEE T Biomed Eng

[2] Falconer, K. et. al. (1985) Electromyogr Clin Neurophysiol.

O26

A MODEL OF MUSCLE SPASTICITY IN OPENSIM

Marjolein Van der Krogt[1], Ajay Seth[2], Katherine Steele[2], Lynn Bar-On[3], Kaat Desloovere[3], Jaap Harlaar[1] and Scott Delp[2]

[1]VU University Medical Center, Dept. Rehabilitation Medicine, Research Institute MOVE, Amsterdam, NL
[2]Stanford University, Bioengineering Department, Stanford, USA
[3]KU Leuven, Dept. Rehabilitation Sciences, Leuven, BE

INTRODUCTION

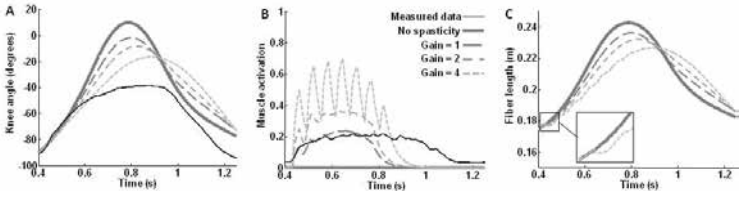
Computer simulations of human movement are commonly used to study normal and abnormal gait, for instance of subjects with spasticity. However, they generally do not include explicit models of spasticity. Our goal, therefore, was to develop a computer model of spasticity and to test this model by dynamic simulation of instrumented spasticity tests.

PATIENTS/MATERIALS and METHODS

Spasticity was modelled in OpenSim[12] using a controller plug-in. This controller excites any muscle to which it is assigned when the muscle fibres are stretched faster than a specified "threshold" velocity. Following Lance[3], the spastic excitation was dependent only on fibre stretch velocity, which was multiplied by a constant "gain". A "delay" was used to represent the stretch reflex latency. To test the spasticity model, forward dynamic simulations were created of instrumented spasticity test data of the hamstrings[4], collected on a female subject with cerebral palsy (15 y, 1.60 m, 52 kg). The knee was manually extended at three different velocities with the subject supine and the hip fixed. The force exerted on the shank, the knee angle, and EMG were measured. The scaled musculoskeletal model was put into the position measured at the beginning of the test and the measured forces were imposed on the model. The model was run forward in time, and the resulting movements, muscle length and velocity, and muscle activation were evaluated. Simulations were run without and with spasticity, simulated with different values for gain, threshold, and delay.

RESULTS

Without spasticity, the simulation overestimated knee extension, muscle activation was zero, and the muscle fibres extended smoothly (see Figure). When adding the spastic controller to the semitendinosus muscle, the muscle reacted to the stretch by becoming active, resulting in lower peak knee angle, slower fibre lengthening velocity, and lower peak fibre length. On close examination, an abrupt stop ('catch') was seen in the fibre length change (Fig.C, zoom). With increasing gain, a more spiky pattern was seen in muscle activation (Fig.B), resembling a clonus effect. Increasing threshold and delay moderated the effects of the spastic controller. The experimental knee angle could be reproduced well by optimizing the model's parameters, but only if muscle contracture as present in the subject was included.



DISCUSSION & CONCLUSIONS

With a spasticity model dependent only on muscle fiber velocity, spastic behaviour can be predicted, including a sudden increase in muscle activity, a break ('catch') in the stretch of the muscle, and clonus. Prolonged muscle activity beyond the duration of the stretch, as often observed in patients with spasticity including our test subject (Fig.B, black line). was not predicted by our model. Future steps include testing the model on subjects with different levels of spasticity and applying the model to evaluate the effects of spasticity on the performance of dynamic tasks such as gait.

REFERENCES

[1] Delp et al. 2007 IEEE Trans Biomed Eng 54, 1940-1950 [2] Seth et al. 2011 IUTAM, v2 212-232; [3] Lance 1980, In Feldman et al, Chicago 485-495; [4] Desloovere et al. 2011 Dev Med Child Neurol, 53 (S5): 4-5

O27

STRICTLY ENFORCING THE RIGID BODY CONSTRAINT IMPROVES THE PERFORMANCE OF A FUNCTIONAL MODEL CALIBRATION METHOD: RESULTS FROM A MECHANICAL ANALOG OF THE LEG

Adam Rozumalski[1], Michael H. Schwartz[1] and Bruce A. MacWilliams[2]

[1]Gillette Children's Specialty Healthcare, St. Paul, Minnesota, USA
[2]Shriners Hospitals for Children, Salt Lake City, Utah, USA

INTRODUCTION

Recently it has been shown that a sphere fitting (SF) technique performed the best of four different functional methods when determining the center of rotation (CoR) for the hip and axis of rotation (AoR) for the knee [1,2]. The goal of this study was to include a previously excluded coordinate transformation (CT) technique applied both with and without a rigid body constraint. This will provide a more rigorous comparison between the methods and independent, experimental assessment of how much the rigid body constraint improves hip center and knee center location and knee axis orientation.

PATIENTS/MATERIALS and METHODS

Data collection and analysis techniques have been previously reported [1]. Briefly, the testing was performed using a deformable mechanical analog of the lower limb designed to mimic skin motion. For this study a new CT approach proposed by Ehrig et al. [4,5] was compared to the SF method (Gamage). The CT method was applied both with and without first applying a Procrustes algorithm to the data to enforce the rigid body constraints on segmental markers.

RESULTS

Adjusting for ROM, level of STA, and the interactions between them, and ignoring sign, the only significant difference between the SF and CT methods was in knee external rotation alignment (mean difference 1.8°, $p < 0.001$) [Fig 1].

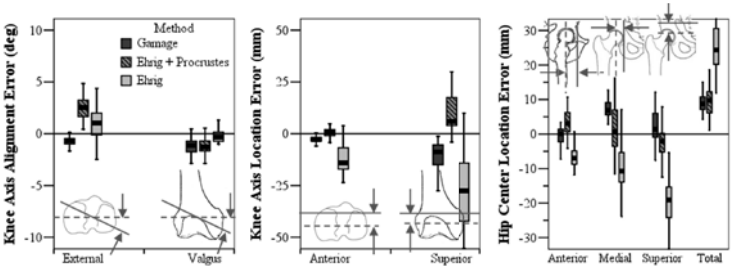


Figure 1. Hip and knee joint error when using the three different functional methods: sphere fitting (Gamage), coordinate transformation with rigid body constraint (Ehrig + Procrustes), and coordinate transformation without rigid body constraint (Ehrig).

DISCUSSION & CONCLUSIONS

The Ehrig + Procrustes method performed as well or better than the SF method proposed by Gamage. The Ehrig method alone performed similarly to the other two CT methods in the previous study. When the rigid body constraint was applied however, the performance of the method improved dramatically at both the hip and knee. This confirms the finding of Ehrig et al., who indirectly showed that applying the rigid body constraint improves the accuracy and repeatability of the hip center [3]. The conclusion of the current study is that most functional methods, when applied correctly, perform equally well and provide an accurate and objective assessment of the patient's underlying anatomy.

REFERENCES

1) MacWilliams (2008). *Gait Posture*, 28(4), 673-9. **2)** Gamage & Lasenby (2002). *J. Biomech.*, 35(1), 87-93. **3)** Taylor *et al.* (2010). *Gait Posture*, 32(2), 231-6. **4)** Ehrig *et al.* (2006). *J. Biomech.*, 39(15), 2798-809. **5)** Ehrig *et al.* (2007). *J. Biomech*, 40(10), 2150-7.

O28

IMPROVING REPEATABILITY OF SETTING VOLUME ORIGIN AND COORDINATE SYSTEM FOR 3D GAIT ANALYSIS

Elyse Passmore[1] and Morgan Sangeux[1]

[1]Royal Children's Hospital, Hugh Williamson Gait Analysis Laboratory, Melbourne, Australia

INTRODUCTION

In 3D gait analysis, setting the point of origin & coordinate system for the capture volume is important since the position & orientation of the cameras & forceplates (FP) are set relative to it. The standard method used for Vicon systems is a calibration wand inserted in the gaps between forceplates, which introduces error during replacement. A new calibration object (L-Frame) was instigated involving four markers screwed into the floor, ensuring consistent placement.

PATIENTS/MATERIALS and METHODS

Our laboratory is equipped with 5 inline OR6-7 AMTI FPs separated by 2mm gaps. 3 different volume origin & coordinate systems were set, 1 using the L-Frame & 2 utilizing the wand object, the 1st set at corner of FP1 & the 2nd at corner of FP3, figure 1(a). Data collection was performed utilising Vicon Nexus 1.7.1 with 10 MX T160 cameras. Full camera calibration was performed immediately prior to data collection. Each calibration object was placed 3 times followed by the set volume origin operation resulting in 9 different system settings. 10 walking trials of one healthy adult were performed resulting in 11 left & 7 right gait cycles with good FP strikes. Each walking trial was processed with the 9 settings. The subject's stride-to-stride repeatability (SSR) was compared with the variability arising from the 3 placements of each set-up, for the hip, knee & ankle moments in sagittal & coronal planes. Variability of a group of curves was computed as the root mean square (RMS) of the difference between the max & min on a point by point basis over stance phase. SSR was taken from the 4 left strides on FP1 from a single calibration using the L-Frame. Variability arising from replacement of a calibration object for a set-up was the average RMS of the 3 versions of each trial.

RESULTS

Wand-1 replacement showed the highest variability for all joint moments, as seen in figure 1(b). Wand-1 variability was seen in the sagittal & coronal planes with 44% & 84% of SSR respectively. The coronal plane ankle moment showed the most influence, 125% of SSR. L-Frame replacement showed little variability, 2% of SSR for sagittal & coronal planes. Wand-3 replacement introduced little variation in the sagittal plane, the effect was more noticeable in the coronal plane, 29% of SSR.

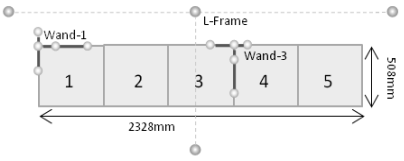


Figure 1(a) - FP configuration and calibration object placement.

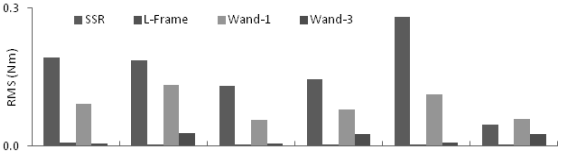


Figure 1(b) - Variability of joint moments for replacement of calibration object.

DISCUSSION & CONCLUSIONS

Having a consistent means of setting the point of origin & coordinate system for the capture volume is important to assure reliable measurements during 3D gait analysis. This was achieved by utilising the L-Frame calibration method, which demonstrated the least amount of variation from calibration object replacement. Inaccurate setting of the volume origin has the most influence on the joint moments, particularly in the coronal plane.

REFERENCES

O29

VOLUMETRIC MOTION ANALYSIS - A SIMPLE AND ACCURATE WAY OF MEASURING 3-DIMENSIONAL REACH IN CHILDREN

Stefan Gantelius[1], Anna Lennartsson[1], Eva Pontén[1] and Elena Gutierrez-Farewik[2]

[1]Karolinska Institutet, Women´s and Children´s health, Stockholm, Sweden
[2]Royal Institute of Technology, KTH Mechanics, Stockholm, Sweden

INTRODUCTION

Cerebral palsy (CP) is a motor disorder due to a brain injury before the age of two. CP is a relatively common impairment, affecting 2-2.5/1000 live births in developed countries. Children with CP often have hypertonic muscles that create an imbalance around a joint. In the upper extremity this imbalance may cause a characteristic pattern of elbow flexion, wrist flexion, forearm pronation, finger flexion and a thumb-in-palm deformity, all contributing to a limited reach. Treatment may include orthopedic surgery, spasticity-reduction, casting, bracing, stretching and training in order to increase or prevent, a decreased range of motion. Today, common evaluation measures of treatment effect are subjective and often time consuming. The aim of this project is to develop a time-efficient, reliable and accurate measure of 3-D reach in children with CP. We present the results from the method development in typically-developing (TD) children.

PATIENTS/MATERIALS and METHODS

TD children (n=15), age 4-18, were assessed. Upper extremity volumetric range of motion was analyzed using an 8-camera motion capture system (Vicon Oxford, UK). Nineteen reflective markers were attached to the arms, head and trunk with the biomechanical model used. The total reaching volume for each arm was detected while the child performed circular movements anterior, posterior, lateral, and superior to the body. The volume of the virtual shape made by the hand marker trajectories relative to the trunk segment was calculated using a Convex Hull method in MATLAB ©. Volume was divided by arm length, measured from the acromion to the third metacarpophalangeal joint, to obtain a volume index independent of arm length.

RESULTS

There was no difference in volume index comparing dominant (2,876 +/- 0,431) and non-dominant (2,984 +/- 0,459) hand, indicating that the reach is the same in both arms in TD children.

DISCUSSION & CONCLUSIONS

Volumetric motion analysis is a simple, quick, and accurate way of measuring 3-dimensional reach in typically developing children; this motion analysis took approximately 10 minutes and was shown in a former study to be sensitive to treatment changes [1]. In future studies it could be a good measure of treatment effect of training, botulinum toxin injections and hand surgery in children with e.g. cerebral palsy due to its high feasibility and comprehensible measurement results.

REFERENCES

1.) Gutierrez-Farewik E.M., Munaretto J., Pontén E.: Towards a new protocol for motion analysis of the upper extremities in hemiplegic cerebral palsy. European Society of Movement Analysis of Adults and Children, September 2006, Amsterdam, the Netherlands.

EXPERT ASSESSMENT OF CONVENTIONAL AND FUNCTIONAL TECHNIQUES TO DETERMINE THE KNEE AXIS

Morgan Sangeux[1], Rowan Habel[1], Jill Rodda[1], Adrienne Fosang[1], Pam Thomason[1] and Richard Baker[2]

[1]Royal Children's Hospital, Hugh Williamson Gait Analysis Laboratory, Melbourne, Australia
[2]University of Salford, Manchester, United Kingdom

INTRODUCTION

Accurate definition of the knee axis is a difficult task. Conventional methods, where physical markers are aligned with the axis, or functional methods, where the axis is inferred from the knee movement have been presented to estimate its position. Although studies have tried to determine the best method on healthy subjects, [1, 2], conclusions may be different in clinical settings, where patients may have abnormal knee movement or difficulty performing the functional task. Another difficulty is the absence of a gold standard to compare the knee axis to. In this context, clinicians can only visually check the adequacy of their estimate of the knee axis. The aim of this study was to obtain the expert agreement and ranking of different techniques to locate the knee axis in a paediatric clinical population.

PATIENTS/MATERIALS and METHODS

Eighty patients were randomly selected retrospectively. One left and right strides were processed according to 1 conventional and 2 functional techniques and displayed independently to four experts together with a coronal video of the patients walking. The curves displayed were the knee flexion-extension, knee abduction-adduction and femur transverse rotation curves. For each patients the experts gave a ranking, (1: best, 3: worst) to the different models and choose whether they strongly agreed, partially agreed, partially disagreed or strongly disagreed with the models. Agreements were converted in scores of 1, 0.75, 0.25 and 0 respectively. The conventional model used the Knee Alignment Device whereas the functional models used a knee flexion-extension exercise. The first functional model assumed a single hinge axis for the knee between 20 and 90 of flexion whereas the second model assumed two non-orthogonal hinges axes for flexion and rotation. Where required, the functional task was performed by the subjects using a supportive device and assisted by the physiotherapist.

RESULTS

The conventional, single hinge functional and two hinge functional models were ranked 53%, 48% and 39% as 1st or equal 1st choice respectively. Between assessor's Fleiss kappa, 0.23, was significant ($p \leq 0.0005$). An ANOVA ($\alpha < 0.05$) with the agreement score as the dependent variable and the patient, assessor and knee axis model as predictors was conducted in Minitab (Minitab Inc. USA). There was a significant effect of the knee axis model. The post-hoc Tuckey analysis showed a significant difference between the conventional (Av: 0.73) and functional models (0.67 and 0.63) but not between the functional models. Kendall's coefficient of concordance of between assessors agreement score was 0.51.

DISCUSSION & CONCLUSIONS

The above results suggest the conventional technique was the technique of choice and most agreed with. However, with only 53% of 1st choice for the most preferred technique it seems necessary to continue to run the different techniques systematically and concurrently. The between assessors agreement measures of the ranking and agreement score, 0.23 and 0.51 respectively, displayed only fair agreement. Further research is required to develop a more objective measurement of the knee axis accuracy.

REFERENCES

[1] Schwartz MH, Rozumalski A. A new method for estimating joint parameters from motion data. JB. 2005;38:107-16
[2] Sangeux M, Baker R. Reliability of hip and knee curves in gait analysis. JEGM. Miami 2010.

A TABLET COMPUTER "APP" FOR NEUROMUSCULOSKELETAL PHYSICAL EXAMINATION IN CHILDREN WITH CEREBRAL PALSY

Kim Van Hutten[1], Jaap Harlaar[1], Lia Out[1] and Merel Brehm[1]

[1]VU University Medical Center, Department of Rehabilitation Medicine, Amsterdam, The Netherlands

INTRODUCTION

Physical examination of neuromusculoskeletal and movement-related functions is commonly performed in children with cerebral palsy (CP). Next to instrumented gait analysis, neuromusculoskeletal physical examination (NMS-PE) is an essential element in clinical decision-making, especially when orthopaedic or neurosurgery is indicated. Taking a complete NMS-PE is rather extensive, so the examination and its registration can take quite some time. Accordingly, not all NMS-PE items are always performed, leading to incompleteness of data. Also paper based forms are subjected to data entry mistakes, and might even get lost. Altogether, this may result in suboptimal decision-making. The quality of NMS-PE will be improved by technology that supports taking a PE. The aim of this project was to develop an innovative, easy to use tool (an "app") for data entry and data storage of NMS-PE findings in children with CP.

PATIENTS/MATERIALS and METHODS

The content of the NMS-PE tool is based on a recently published guideline book [1]. Requirements and a functional design of the app were drafted in close cooperation with health-care professionals. Based on these requirements, a user interface was developed, as well as a database to store the entered data. A prototype of the NMS-PE app was tested in a pilot study. During the pilot study, NMS-PEs were performed in children with CP whom were seen for a first appointment at the outpatient clinic of a university hospital. Examinations were performed with the old method (manual data entry on paper sheets) and with the new method (digital data entry) on a second cohort. Factors of success and failure were documented during the pilot. Furthermore, efficiency (time to perform the examination), completeness of data registration (% completed items) and satisfaction were evaluated.

RESULTS

A practical and easy to use tablet computer app was build for the NMS-PEs in children with CP (see photo's). The app consists of a front-end, the user-interface installed on a tablet pc (iPad 2, Apple), and a back-end, the database (SQL) to store the entered data. Physical examinations were performed in 25 children with CP (old and new method). Results show that completeness of data registration increased from 65% in the old method to 80% in the new method. Efficiency of performing the examinations was increased with 18% (i.e. from 28 minutes in the old method to 23 minutes in the new method). Satisfaction with respect to ease of use was rated with a 7 (on a scale of 1 to 10), and feasibility of working with the app was rated with an 8.

DISCUSSION & CONCLUSIONS

Positive reactions on feasibility of working with the newly developed physical examination tool, combined with increased standardization, efficiency and completeness of data show that a digital method of data entry and data storage can be extremely useful in clinical practice. As such, it can add to the quality of the physical examination in children with CP, which is especially important for children who are indicated for complex operations.

REFERENCES

[1] Becher et.al. Reed Business 2012; Amsterdam, The Netherlands.

Notes

Friday Sept 14

	A2, Main Lecture Hall, Level 6	C4, Lecture Room, Level 2
09.00-10.00	Session 4a Orthotics	Session 4b Adult Orthopeadics
10.00-10.30	Coffee in the Exhibition Hall	
10.30-12.00	Session 5a Upper Extremity	Session 5b Foot
12.00-13.00	Lunch and Coffee in the Exhibition Hall	
13.00-14.30	Poster Session in the Exhibition Hall & Balcony Orthopeadics, Sports and Technical	
14.30-15.00	Keynote Lecture II Hans Forssberg	
15.00-15.30	Coffee in the Exhibition Hall	
15.30-17.00	Session 6a Cerebral Palsy Effect	Session 6b Gait Assessment
19.30	Gala Dinner at Junibacken	

MOTION LAB SYSTEMS

Advanced EMG Systems

MA-300

Five MA-300 EMG Systems to choose from!

All Systems Include:

- EMG Channels - 6, 8, 10, or 16
- Full Set of Preamplifiers
- EMG Graphing Software
- Minimum 10-1000Hz Bandwidth

Advanced Systems Also Include:

- Custom Preamp Combinations
- Bandwidth up to 2kHz
- Additional 4 Research Channels
- 8 Dedicated Events Channels
- 8 Setting Low Pass Filter

"Motion Lab Systems provides our lab with more than just a good EMG system. They understand our special needs and challenges and go above and beyond to help."
Nicholas J. Gryfakis, M.S., Manager/Biomedical Engineer , Children's Memorial Hospital , Chicago

System Comparison	MA300-X Systems		Advanced EMG Systems		
	MA300-XII	MA300-XVI	MA300-18	MA-300-22	MA300-28
Total Channels	12	16	18	22	28
EMG/Multi-Use Channels	8	16	6	10	16
Extra Research Channels	4	0	4	4	4
Dedicated Event Channels	0	0	8	8	8
Package Included	Standard System Package		Enhanced EMG System Package		
EMG Bandwidth	10-1000 Hz -3dB		10-2000 Hz -3dB		
Variable Low Pass Filter	No		Yes- 8 Position LP Filter Included		
Preamplifier Options	Gel Snap Preamplifier		User Selected- Gel/Surface/ Fine Wire,		
Connector Material	Plastic Binder		Metal LEMO or Plastic Binder Options		
Software Included	EMG Graphing Software		Advanced EMG Analysis Software		
Backpack Support	Adult Belt		Adult and Child Sized Vests		
Event Switches Included	No		Yes		

NEW WIRELESS OPTION: New and existing MA300 users can now easily and affordable upgrade to wireless! Plugs right in. Clean, real time data!

www.motion-labs.com
Baton Rouge, Louisiana, USA
Email: sales@motion-labs.com
Ph: (225) 272-7364 Fax: (225) 272-7336

FRIDAY, SEPTEMBER 14, 2012

09.00 - 10.00	**SESSION 4a (A2)** **Orthotics** **Chairmen: Richard Baker, Andrew Murphy**
O32 Skaaret, Ingrid	The impact of ankle-foot orthoses one year post orthopaedic surgery in children with Cerebral Palsy
O33 Ries, Andy	Do Ankle-Foot Orthoses Improve Gait for Individuals with Cerebral Palsy?
O34 Bartonek, Åsa	Comparison of two carbon fibre spring orthosis on gait in children with Myelomeningocele
O35 Eriksson, Marie	Oxygen cost during walking in children with Arthrogryposis
O36 Block, Julia	Sit to stand movement supported by an active orthosis
O37 Frechtel, Asaf	Comparison of dynamic muscle activity and 3D gait kinematics acquired while wearing an electronic stance control orthosis versus a locked knee-ankle-foot orthosis: a case study

09.00-10.00	SESSION 4b (C4) Adult Orthopeadics Chairmen: Maria Grazia Benedetti, Han Houdijk
O38 Dickens, Wendy	Lower limb kinematics following pelvic support osteotomy for unilateral avascular necrosis of the femoral head
O39 Meyer, Chistoper	Early clinical gait analysis of patients following direct anterior approach total hip Arthoplasty: preliminary results
O40 Holsgaard-Larsen, Anders	Evaluating lower-limb asymmetry in ACL-patients: assesment of jumping performance and mechanical muscle function
O41 Tengman, Eva	One-leg hop - kinematic analysis ~20 years after anterior cruciate ligament injury.
O42 Barnett, Cleveland	The role of the intact limb in the adaptation of transtibial amputee obstacle crossing following rehabilitation
O43 Heitzmann, Danielle	Gait strategies of transfemoral amputees descending slopes

THE IMPACT OF ANKLE-FOOT ORTHOSES ONE YEAR POST ORTHOPAEDIC SURGERY IN CHILDREN WITH CEREBRAL PALSY

Ingrid Skaaret[1], Merete Aa Fosdahl[1], Bjorn Lofterod[1], Inger Holm[1, 2]

[1]Oslo University Hospital, Oslo, Norway
[2]University of Oslo, Oslo, Norway

INTRODUCTION

Lower limb orthopaedic surgery is often necessary in order to facilitate and prolong efficient gait in children with cerebral palsy. In the postoperative period ankle foot orthoses (AFO) are used to preserve the effect of the surgery. Such orthoses are made with different designs, typically constructed according to guidelines specified by the pre-operative gait analysis and overall treatment plan. The contribution of AFO's to influence gait function after surgery has only been investigated to a small degree. The aim of the present study was to evaluate the impact of AFO's on selected gait variables at the time of routine three-dimensional gait analysis (3DGA) ≥1 year post lower limb surgery in children with bilateral spastic cerebral palsy (BSCP) using the Gait Profile Score (GPS) and Movement Analysis Profile (MAP) [1] to quantify kinematic outcome.

PATIENTS/MATERIALS and METHODS

23 subjects with BSCP (preop 11±2,5, postop 13±2,5 ages), GMFCS level I-III, who underwent postoperative 3DGA (MXF40 Vicon system, 3 AMTI force plates), walking with and without AFO's were included. Data from three walking situations; (1) preoperative barefoot, (2) postoperative barefoot and (3) postoperative wearing AFO's were compared for temporal spatial variables and using GPS and MAP scores for pelvic, hip, knee and ankle kinematic data. ANOVA and post hoc (Bonferroni) tests were used to examine significant differences between the situations.

RESULTS

Using AFO's, stride length significantly increased while maintaining velocity and reducing cadence. Hip and pelvis sagittal plane MAP scores were significantly and equally reduced in both postoperative situations. Scores for knee and ankle sagittal plane, hip rotation and foot progression were significantly reduced postoperatively with higher, but non-significant reductions using AFO's. The highest postoperative reductions in MAP scores of 8.4° for barefoot and 9.5° for AFO situations were seen in the knee sagittal plane variable ($p<0.000$).The overall GPS was significantly reduced in both postoperative conditions ($p<0.000$), with a mean difference of 4.7° walking barefoot and 5.2° wearing AFO's.

DISCUSSION & CONCLUSIONS

After years of rehabilitative treatment to improve function, there is often an inherent expectation that the surgery and the patients' post-operative efforts would improve the gait function to such an extent that orthoses would be redundant. However, the results from this study confirm additional improvement that to some extent justifies recommendations based on the post-operative 3DGA that promoted continued use of AFO's in 37 of the 46 limbs. GPS and MAP results are comprehensive tools in evaluating the outcome after surgery, but do not offer detailed information concerning joint motion in the various parts of the gait cycle. There is a need to further investigate the contribution of AFO's influence on gait function after lower limb surgery and to evaluate the correlation between clinical judgements and results from 3DGA.

Significant reductions of GPS and MAP variables confirm gait patterns that are less different from typically developing children one year post lower limb surgery. In addition, results indicate additional improvement on several gait variables using AFO's.

REFERENCES

[1] Baker R et al, Gait Posture 2009; 30: 265-269

DO ANKLE-FOOT ORTHOSES IMPROVE GAIT FOR INDIVIDUALS WITH CEREBRAL PALSY?

Andrew J Ries[1, 2], Adam Rozumalski[3, 2], Michael H Schwartz[3, 4, 2]

[1]University of Minnesota, Mechanical Engineering, Minneapolis, USA
[2]Gillette Children's Specialty Healthcare, Center for Gait and Motion Analysis, St. Paul, USA
[3]University of Minnesota, Biomedical Engineering, Minneapolis, USA
[4]University of Minnesota, Orthopaedic Surgery, Minneapolis, USA

INTRODUCTION

The prescription of ankle foot orthoses (AFOs) is a standard treatment of patients diagnosed with cerebral palsy (CP). Typical AFO types are solid (SAFO), posterior leaf spring (PLS), and hinged (HAFO). Selection of a specific type of AFO is not always straightforward. Different prescription methods have been proposed [1], but none have been shown to be optimal. The ability to gage the effectiveness of current prescription methodologies is critical.

PATIENTS/MATERIALS and METHODS

A search of the clinical database was conducted. Inclusion criteria were a primary diagnosis of diplegic CP, and walking trials for both barefoot (BF) and wearing orthoses (ORTH) at a single visit. Motion data was analyzed and the change in GDI from BF to ORTH was calculated; positive change indicates improvement. The GDI score is a single number that represents the overall gait pathology (GDI>100 normal gait kin;10 point decriment is one std dev from norm)[2].

RESULTS

The average GDI change was an improvement of +1.6 from BF to ORTH. Assistive device use, barefoot GDI, and the interaction between these two variables were significant predictors of the GDI change ($p<0.05$). Overall, subjects with poorer kinematics (lower GDI) derived greater benefit than those with milder gait deviations. Compared with independent ambulators, subjects with assistive devices derived greater benefit from AFO use; even after adjusting for their lower overall GDI [Figure 1]. The association of change in GDI with barefoot GDI was slightly smaller among dependent ambulators compared to their independent counterparts (slope = -0.13 vs. -0.20 respectively).

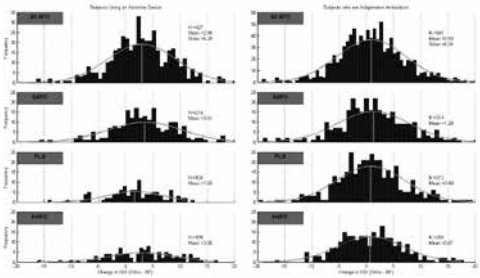


Figure 1 - Small overall improvements across groups. Differences between designs were not significant.

DISCUSSION & CONCLUSIONS

A retrospective analysis showed a small benefit among subjects requiring assistive devices, but nearly negligible improvements for independent ambulators. The current prescription paradigm for AFOs is shown to produce only minimal improvements in gait. The distribution of GDI changes suggests that while overall response to AFO wear is underwhelming, there are a significant number of good responders (*i.e.* GDI changes of >5). Future work should focus on identifying patient characteristics that lead to positive changes.

REFERENCES

[1] Rodda J and Graham HK, *European Journal of Neurology*, **8:**98–108, 2001.

[2] Schwartz MH and Rozumalski A, *Gait Posture,* **28:**351–7, 2008.

COMPARISON OF TWO CARBON FIBRE SPRING ORTHOSES ON GAIT IN CHILDREN WITH MYELOMENINGOCELE

Åsa Bartonek[1], Ruoli Wang[2], Marie Eriksson[1] and Elena M Gutierrez-Farewik[2]

[1]Karolinska Institutet, Women's and Children's health, Stockholm, Sweden
[2]Royal Institute of Technology, KTH Mechanics, Stockholm, Sweden

INTRODUCTION

A carbon fibre spring orthosis with restoring energy effect enhances gait function in children with motor disorders by improving ankle plantarflexion moment, ankle positive work, and stride length (1). In recent years, the orthotics company have further developed the carbon fibre spring design with the aim to improve the first ankle rocker by increasing the range of plantarflexion motion while leaving the range of dorsiflexion motion unchanged. The aim of this study was to evaluate whether any gait parameters changed with this new carbon fibre spring design during walking.

PATIENTS/MATERIALS and METHODS

Nine children with low or midlumbar Mylomeningocele (age 14.1, SD 2.7 years) participated in a gait study. The children were tested with their standard carbon fiber spring orthosis (SO) and the new developed spring-split orthosis (SSO) (Gottinger). Both orthoses consist of an L-shaped carbon fiber component which is embedded in a composite material with a foot section and calf section. A distance of a few millimeters between the foot segment and the carbon fiber spring is allotted for the spring to flex during the stance phase to store energy during midstance and return it at pre-swing. The difference between SO and SSO is in the heel area of the spring; compared to the SO, the mechanical construction of the SSO is aimed to increase the plantarflexion angle just after heel contact, i.e. during the first ankle rocker, whereas dorsiflexion during stance should not be influenced by the material change in the SSO. All children underwent 3D gait analysis using an eight-camera motion analysis system (Vicon MX40, Oxford) along a 10m walkway with two embedded force plates (Kistler, Switzerland). The torsional spring constants in dorsiflexion and plantarflexion were tested as elastic torsional stiffness. A 2-way ANOVA with within-subject factors of side (2 levels) and orthoses type (2 levels) was performed (SPSS) with a significance level of 0.05.

RESULTS

The SSO was found to be approximately 33% less stiff in plantarflexion than the SO ($p=0.033$). The only kinematics differences observed was greater knee flexion during swing with the SSO than with the SO (mean ± standard error: SO: 57.8° ± 3.0°, SSO: 60.2° ± 2.7°, $p=0.022$). No difference in dorsiflexion angle at initial contact or in amount of movement towards plantarflexion during the first ankle rocker was found between the orthoses types. With SSO, significantly less maximum plantarflexion moment, maximum ankle power generation ($p=0.016$), and maximum ankle power absorption ($p=0.025$) than with SO were found. No differences in temporal-parameters were found.

DISCUSSION & CONCLUSIONS

In agreement with the design aim of the SSO vs the SO, we have found that the SSO has a lower plantarflexion stiffness. This decrease in stiffness, however, could not be confirmed during gait by increased plantarflexion motion during the first ankle rocker (initial contact to foot flat) contact; plantarflexion motion during the first ankle rocker was found to be unchanged. However, the significantly less maximum ankle power absorption with the SSO versus the SO indicates less energy storage during dorsiflexion in the SSO carbon spring than in the SO. This may also have influenced the significantly lower ankle plantarflexion moment with the SSO versus the SO. All children in the study chose to continue wearing the SSO, and 8/9 parents reported that their child’s gait improved with the SSO.

REFERENCES

(1) Bartonek Å et al Dev Med Child Neurol 2007;49 615-620

OXYGEN COST DURING WALKING IN CHILDREN WITH ARTHROGRYPOSIS

Marie Eriksson[1], Li Villard[1] and Åsa Bartonek[1]

[1]Karolinska Institutet, Dept of Women´s and Children´s Health, Stockholm, Sweden

INTRODUCTION

Arthrogryposis Multiplex Congenita (AMC) can be described as a complex condition characterized by deformed joints [1]. To compensate for lower extremity deformities and muscle weakness, orthoses are often used and different gait patterns in children with AMC have been identified [2]. The ambulatory activity level has been reported as lower in children with AMC compared to typical developed youth [3], however, no study on energy consumption has been found. The aim of this study was therefore to measure oxygen (O2) cost in children with AMC during walking.

PATIENTS/MATERIALS and METHODS

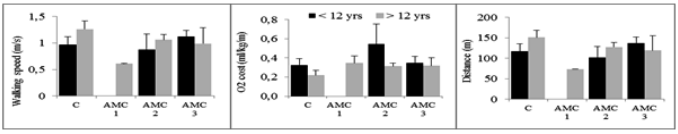
21 children with AMC, 5.0 – 17.0 (median 12.8) years, and a control group (C) consisting of 24 age-matched children, 5.1 – 16.8 (median 12.2) years participated in the study. A Cosmed K4b² (Cosmed, Italy) was used to measure O2 cost during walking at self-selected speed during 5 minutes of which the two last minutes were analysed. Children with AMC were divided into three groups based on orthoses use; AMC 1 using knee-ankle-foot orthoses with locked knee joints (KAFO-L), AMC 2 using ankle-foot orthoses (AFO) or KAFOs with open knee joints (KAFO-O) and AMC 3 using footwear. Non-parametric test was used to compare values between the AMC and control groups. Significant differences were determined at the $p \leq 0.05$ level.

RESULTS

Data is presented in age groups <12 years and >12 years (Fig.)

Age group >12 years: With respect to the entire study group, the lowest O2 cost *(p<0.000)*, the highest walking speed *(p=0.001)*, and the longest walking distance *(p=0.001)* were seen in C-group >12 years. O2 cost was similar in the AMC groups but higher than in the C-group *(p=0.007)*. Walking speed differed between the AMC groups and the C-group, with the highest in the C-group, and the lowest in AMC 1 *(p=0.009)*. Walking distance differed between the AMC groups and the C-group, with the shortest distance covered by AMC 1 *(p=0.009)*.

Age group <12 years: There were no children using KAFO-L (AMC group 1). No significant differences were found between the AMC groups and the C-group neither in O2 cost, walking speed, nor in walking distance. O2 cost was higher in AMC 2 than in AMC 3 and the C-group. AMC 3 had higher walking speed and walked longer distance than AMC 2 and the C-group.



DISCUSSION & CONCLUSIONS

The highest O2 cost was found in children with AMC <12 years walking with KAFO-O or AFO, which may be explained by the heterogeneous representation in hip muscle strength among the children in this group. The children in AMC 1 who had similar good muscle strength in hip extensors but needed more extensive orthotic solutions (KAFO-L) and were totally dependent on orthoses to achieve walking ability, had similar O2 cost compared to the other AMC groups in the same age group. Slowing down the walking speed seems to be a strategy in some of the AMC groups, in particular in the children with KAFO-L.

REFERENCES

[1] Hall 1997 [2] Eriksson et al. 2010 [3] Dillon et al. 2009

SIT TO STAND MOVEMENT SUPPORTED BY AN ACTIVE ORTHOSIS

Julia Block[1], Stefan Van Drongelen[1], Daniel W. W. Heitzmann[1], Roman Müller[2], Markus Grün[3] and Sebastian I. Wolf[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany
[2]TU Darmstadt, Microtechnology Electromechanical Systems Lab, Darmstadt, Germany
[3]TU Darmstadt, Department of Control Engineering and Mechatronics, Darmstadt, Germany

INTRODUCTION

An active knee orthosis has been developed for assisting the elderly in challenging ADL-tasks [1] like stair-climbing or sit-to-stand (STS). In contrast to approaches of exo-skeletal devices, this orthosis aims to amplify knee joint moment in the elderly with reduced muscle strength. Aim of this study was to test whether the user profits from the supportive function of the orthosis. A lower EMG-activation during STS was expected due to the supportiv external moment.

PATIENTS/MATERIALS and METHODS

One healthy subject was tested with a custom made pair of knee-ankle-foot-orthoses with an actuator attached to the right orthosis. Ten symmetric STS movements at self-selected velocity were performed with feet placed on separate force platforms. The subject stood up from a bench placed on a third platform to detect the seat-off-event (SO). Motion was captured via a 12-Camera-Vicon-System. Synchronously, EMG of M. rectus femoris and M. gluteus medius were recorded as well as torque, current and angle of the actuator at 1080 hz. STS-movements were performed with a support of 25% of subject's maximum required knee torque and with zero-moment-regulation of the motor.

RESULTS

A good correlation was found between EMG and motor data (fig.1). Both, activation of M. quadriceps and moment generation by the orthosis starts prior to SO. The maximum activation of M. gluteus medius is reached after the maximum in M. quadriceps. Kinematics and kinetics were similar in both conditions (fig.2). With motor support the extension phase started earlier and the maximum activation of the M. rectus femoris around SO-event was 26% lower. The left side, with a similar but passive orthosis, showed no change in the amount of muscle activation.

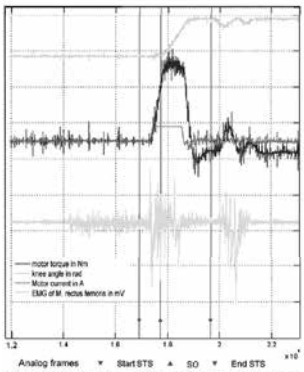


Fig.1: syncronized motor signals and EMG in STS

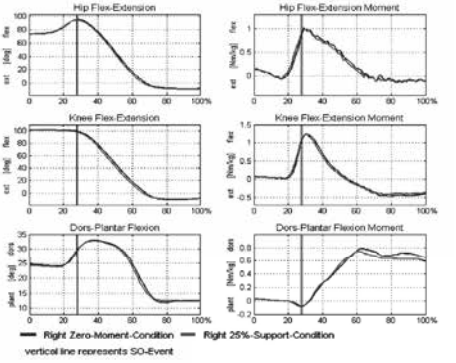


Fig. 2: sagital kinematics and kinetics in supported and zero-moment STS

DISCUSSION & CONCLUSIONS

The unchanged kinetics and kinematics show, that the subject's STS strategy is not influenced by the external torque. Measuring the amount of muscle activation seems to be a sufficient method to show the supportive function of the active orthosis. Further measurements will be performed with additional subjects and motorized orthoses on both sides.

REFERENCES

[1] Luepongsak, N., et al. (2002) Osteoarthritis Cartilage, 10(5): p. 353-9

COMPARISON OF DYNAMIC MUSCLE ACTIVITY AND 3D GAIT KINEMATICS ACQUIRED WHILE WEARING AN ELECTRONIC STANCE CONTROL ORTHOSIS VERSUS A LOCKED KNEE-ANKLE-FOOT ORTHOSIS: A CASE STUDY

Eitan Raveh[1], Isabella Schwartz[2] and Sigal Portnoy[2]

[1]Chemitec Advanced Medical Solutions, Hod Hasharon, Israel
[2]Hadassah Medical Center, The Rehabilitation Department, Jerusalem, Israel

INTRODUCTION

Patients suffering from nervous system injury are often fitted with a locked knee-ankle foot orthosis (KAFO). Consequently, most of these patients adopt abnormal gait patterns and may suffer from hip or low back pain, leading to reduced mobility. An electronic stance-controlled orthosis (SCO) automatically locks the knee joint during the stance phase to provide stability, and unlocks it during the swing phase to allow for knee flexion. We present a case study investigating the gait patterns of an individual ambulating without an orthosis, with a KAFO and with a novel SCO.

PATIENTS/MATERIALS and METHODS

A 23 years old healthy male, 6 years following an accident which resulted in a right leg paralysis, has been using a KAFO since the accident. The subject was fitted with an SCO (E-Mag Active, Otto Bock, Germany). We evaluated the gait patterns and dynamic muscle activation in 3 different states: walking with no orthosis, with the locked KAFO, and with the SCO. The evaluation tools included 3D gait analysis (spatio-temporal parameters, symmetry and 3D joint angles), synchronized with dynamic EMG of the rectus femoris (RF) and gluteus medius (GM) muscles.

RESULTS

We found improved gait symmetry of the swing duration and narrower base width when the subject ambulated with the KAFO, which was further improved when he walked with the SCO. The GM muscle was highly activated while walking without an orthosis, however when using the KAFO, its activity was reduced, and finally, minimal activity was recorded while walking with the SCO. Furthermore, activation of the RF was higher while walking with the SCO. Kinematic results showed the desired knee flexion during swing, achieved by the SCO, as well as higher gait symmetry.

DISCUSSION & CONCLUSIONS

Our results may indicate a more symmetrical and confident gait pattern using the electronic SCO compared with no orthosis or while using a regular KAFO. EMG results may suggest a more normal swing phase, relieving the subject from the need to compensate using hip circumduction movements.

REFERENCES

LOWER LIMB KINEMATICS FOLLOWING PELVIC SUPPORT OSTEOTOMY FOR UNILATERAL AVASCULAR NECROSIS OF THE FEMORAL HEAD

Wendy E Dickens[1], James A Fernandes[2], Emma J Pratt[1] and Michael J Bell[2]

[1]Sheffield Children's Hospital, Gait Laboratory, Sheffield, UK
[2]Sheffield Children's Hospital, Orthopaedic and Trauma Surgery, Sheffield, UK

INTRODUCTION

Avascular necrosis of the femoral head (AVN) has devastating long term consequences for hip joint mobility and lower limb function. Management is complex, there is no accepted gold standard treatment and there has been only limited evaluation of the gait characteristics of this group[1,2,3]. To evaluate the management of this condition functionally, a two-stage study has been undertaken. Stage one, a retrospective cohort study of the gait of young people with femoral head AVN (presented previously) and stage two, evaluation of these patients post pelvic support osteotomy PSO (current paper).

PATIENTS/MATERIALS and METHODS

A standard three-dimensional gait analysis was performed post operatively on 17 patients following PSO for femoral head AVN using a 6- camera Vicon® 370 system, Kistler® force platform and Plug in Gait® software. From a representative cycle for each patient, mean ± 1 standard deviation were calculated for waveform throughout the cycle for affected and unaffected sides. These were compared to the laboratory normal adult dataset (Figure 1.). Paired t-tests were performed where data were normally distributed.

RESULTS

The cohort comprised 11 males and 6 females, mean age 17 years (range 15-19). Initial analysis of the data revealed increased hip excursion and shift towards normal range with associated improvements in pelvic excursion and alignment. There was a shift towards normal timing and magnitude of knee flexion in stance. Length discrepancy persisted in all cases although compensatory equinus was reduced.

DISCUSSION & CONCLUSIONS

Analysis of three dimensional gait analysis post pelvic support osteotomy for unilateral avascular necrosis of the femoral head, revealed significant improvements in lower limb kinematics. Although residual leg length discrepancy was evident in the majority of the cohort, PSO appears to represents a functionally beneficial surgical option for this group of patients. Further comparative evaluation is required to establish the optimal surgical intervention for this group of patients..

REFERENCES

1. Song K. *et al*. Journal of Pediatric Orthopaedics 2004, **24**:148-155
2. Siegel D. *et al.* Journal of Bone and Joint Surgery 1991, **73-A**:659-666
3. Dickens et al (2008) *Gait Posture* (28) supplement 2: S25.

EARLY CLINICAL GAIT ANALYSIS OF PATIENTS FOLLOWING DIRECT ANTERIOR APPROACH TOTAL HIP ARTHOPLASTY: PRELIMINARY RESULTS

Christophe Meyer[1, 2], Kristoff Corten[2], Davide Monari[3], Jean Pierre Simon[2], Ilse Jonkers[4], Kaat Desloovere[1]

[1]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[2]UZ Leuven, University Hospital Pellenberg, Orthopedic department, Pellenberg, Belgium
[3]KU Leuven, Department of Mechanical Engineering, Leuven, Belgium
[4]KU Leuven, Department of Movement Sciences, Leuven, Belgium

INTRODUCTION

Primary total hip arthroplasty (THA) is a well-established procedure to treat end-stage osteoarthritis (OA) of the hip joint with good results in the elderly population but it still remains a challenge to achieve good long term results in young (<60 years old) and active patients. It is well known that surgical approach is clearly one of the parameters that were found to influence post-operative hip function recovery[1-3], likely as a consequence of peri-operative damage to specific muscles. The last decade, direct anterior approach (DAA) has been successfully introduced and gained popularity for operating young patients as it is a muscle sparing procedure. Therefore, it is expected to lead to a better functional recovery in a shorter period of time than the other procedures. Literature assessing the effect of the direct lateral, posterolateral surgical procedures on the biomechanical behavior during gait is exhaustive, however studies dedicated to DAA are scarce. Consequently, our aim is to assess the effect of the direct anterior approach on the functional recovery of young patients following total hip arthroplasty as measured by gait analysis including gait as well as highly demanding tasks.

PATIENTS/MATERIALS and METHODS

A total of 10 patients (3 women, 7 men) diagnosed with unilateral osteoarthritis and with a median (and interquartile range) age of 48 (41-52) years, height of 1,70 (1,63-1,82) cm, weight of 67,1 (59,9-80) kg and body mass index of 25,2 (21,7-26,6) kg/m², volunteered to participate in this study. Three dimensional gait analysis was performed pre-operatively and at 3 months post-operatively. Patients were fitted with 35 passive retroflective markers (14-mm) located on the lower limbs, pelvis, and trunk (Total body Plug-in-Gait marker set, Vicon). Three-dimensional motion analysis was performed using an optical data capturing system for determination of 3D markers trajectories. Ground reaction force, synchronized with the motion capture system, was also collected for gait cycle definition and kinetic analysis. All patients performed three trials of overground (level) walking, stair ascent and descent, lunge and chair rise at a self-selected pace. Kinematics and kinetics were visualized and parameters were extracted using custom-build Matlab software. For each condition, average data were computed. By means of statistical software, repeated measures ANOVA were performed to compare the pre-operative and the post-operative data. Comparison with controls was performed using the Student's t test.

RESULTS

For most conditions, there was a significant improvement in the sagittal plane for hip range of motion between the pre-operative and the post-operative data. Although not significant, we observed an improved hip abduction as well extension moment during the stance phase. These values were closer to normative data.

DISCUSSION & CONCLUSIONS

Our results showed that there was a clear improvement in gait mechanics from pre-operative to early post-operative period and that patients do not reach controls level yet but are relatively close. However, our group is too small and heterogeneous to draw any strong conclusions. Therefore, we would extend our study group.

REFERENCES

[1]. Lugade Vet al. Clinical Biomechanics 2010;25:675-80.

[2]. Mayr E et al. Clin Biomech (Bristol , Avon) 2009;24:812-8.

[3]. Whatling GM et al.Journal of Engineering in Medicine 2008;222:897-905.

EVALUATING LOWER-LIMB ASYMMETRY IN ACL-PATIENTS: ASSESMENT OF JUMPING PERFORMANCE AND MECHANICAL MUSCLE FUNCTION

Anders Holsgaard-Larsen[1], Tine Iversholt[2], Carsten Jensen[1], Niels HM Mortensen[1] and Per Aagaard[2]

[1]Odense University Hospital, Institute of Clinical Research, University of Southern Denmark, Orthopaedic Research Unit, Department of Orthopaedics and Traumatology, Odense, Denmark
[2]University of Southern Denmark, Institute of Sports Science and Clinical Biomechanics, Odense, Denmark

INTRODUCTION

The ratio between the operated and non-operated leg is typically used to distinguish between normal or abnormal test scores in knee patients (1). Traditionally, the asymmetry ratios are investigated by use of functional tests (i.e. one-leg jump for distance). However, mechanistic outcomes such as kinematic/kinetic data and isolated muscle force/power output may provide further insight into the origin of between-limb asymmetry. The study aim was to investigate differences in asymmetry ratios of unilateral jump performance by means of kinetic and kinematic analysis and mechanical muscle function in ACL-patients and healthy controls.

PATIENTS/MATERIALS and METHODS

This case-control study was performed in 23 ACL-reconstructed men (mean age: 27.2 ± 7.5 years and BMI: 25.4 ± 3.2) 18-30 month post-surgery and 25 healthy matched controls (mean age: 27.2 ± 5.4 years and BMI: 24.1 ± 1.8). Patients and controls performed (i) bilateral maximal counter movement jumps (CMJ) with each leg positioned on a separate force plate and (ii) maximal single-leg CMJs. Kinematic data were synchronously recorded by a 6 camera Vicon MX system. Subsequently, center of mass jump height (JH), unilateral knee joint range of motion (ROM), unilateral peak (Mpeak) and mean sagittal knee moment (Mmean) were analyzed for the concentric phase, (iii) one-leg maximal jump for distance was performed (1), and (iv) maximal unilateral isometric knee extensor and flexor strength (MVC) were measured using stabilized dynamometry (2). Asymmetry ratios were calculated as operated/non-operated leg for ACL-patients, and non-dominant/dominant leg for controls. Good-to-moderate test-retest reliability has been reported for all measured variables (3). Differences in asymmetry ratios were evaluated by student's t-tests using a 0.05 level of significance.

RESULTS

No differences in age or BMI were observed between groups. CMJ: Asymmetry ratios for knee joint ROM differed ($p<0.01$) between patients and controls in both types of CMJ (96.1% vs. 102.6% and 87.0% vs. 99.9% in bilateral and single-leg CMJs, respectively). Jump for distance: Patients demonstrated greater ($p<0.01$) asymmetry for jump length (92.9% vs. 98.6%). MVC: Asymmetry in hamstring MVC was greater ($p<0.001$) for patients than controls (77.4% vs. 101.3%).

DISCUSSION & CONCLUSIONS

ACL patients showed reduced function of the operated leg 18-30 month post ACL-reconstruction for knee ROM, single-leg jump for distance and hamstring MVC. The most prominent reduction was observed for maximal hamstring muscle strength. This finding has significant clinical implications since the hamstring muscles are important protagonists to the ACL (4,5), with reduced hamstring MVC thus representing a potential risk factor for secondary ACL-rupture.

REFERENCES

1) Gustavsson et al, Knee Surg Sports Traumatol Arthrosc, 14, 778-788, 2006
2) Jensen et al, Osteoarthr & Cartil, 19, 1108-1116, 2011
3) Holsgaard-Larsen et al (abstract), American College of Sports Medicine Annual meeting, MSSE 2012
4) More et al, Am J Sports Med, 21, 231–237, 1993
5) Zebis et al, Am J Sports Med, 37, 1967–1973, 2009

ONE-LEG HOP - KINEMATIC ANALYSIS ~20 YEARS AFTER ANTERIOR CRUCIATE LIGAMENT INJURY.

Eva Tengman[1], Helena Grip[1] and Charlotte Häger[1]

[1]Umeå University, Dept. of Community Medicine and Rehabilitation, Physiotherapy , Umeå, Sweden

INTRODUCTION

Different jumps are often used in rehabilitation after injury of the anterior cruciate ligament (ACL), and commonly jump capacity is quantified as e.g. jump distance, jump height. However, the movement quality during functional tasks is important, and may encompass aspects not reflected simply by distance or height. This study is a long term follow up of subjects with ACL-injury, 17-28 years after injury. The main aim was to evaluate the movement pattern of subjects with an unilateral ACL-injury when performing a maximal distance jump, One-leg hop, and compare the outcome between injured and non-injured leg, and to the performance of healthy controls.

PATIENTS/MATERIALS and METHODS

70 subjects with a unilateral ACL-injury and 33 knee healthy controls have been tested. Of these, 37 subjects (ACL-PT) were treated with tailored physiotherapy (age 48.1±5.9yrs, BMI 28.9±4.6) and the other 33 subjects (ACL-R) underwent reconstructive surgery (age 45.6±4.5yrs, BMI 27.2±3.3, 3.8±2.5yrs between injury and reconstructive surgery). The participants had injured their knee on average 23.4±2yrs ago, both groups. Data of 33 controls have also been collected (age 46.7±5.0yrs, BMI 24.6±2.5). The subjects performed three One-leg hops forward on each leg without shoes and with the arms held across the chest. The kinematics of the One-leg hops were captured using a 3-dimensional motion analysis system (Oqus®, Qualisys Gothenburg, Sweden) with eight cameras (240Hz). The maximum hop distance was determined and Limb Symmetry Index (LSI) calculated as the ratio between the injured and non-injured leg. The maximum angles in hip, knee and ankle for the longest hop, were derived during a time window 1) before jump-off and 2) after landing.

RESULTS

There was a significantly shorter jump distance for the ACL injured leg as compared to the non-injured leg for both ACL-groups (ACL-PT p=0.001, ACL-R p=0.004, linear mixed model). The LSI was for the ACL-PT 92±13%, for ACL-R 94±11%, and for the controls 100±9%. There were no group differences in jump length for the non-injured leg compared to the legs of the controls (One-way ANOVA). ACL-R jumped longer than ACL-PT (p=0.046, linear mixed model). Preliminary kinematic analysis on about half of the subjects indicates no differences in maximum angles when comparing injured to non-injured leg for the ACL-injured, or dominant to non-dominant leg for the controls. However, significant differences seem to exist between the two ACL-groups in knee and hip angles both before jump-off (p=0.002, p=0.036, linear mixed model) and after landing (p=0.004, p=0.003, linear mixed model), where ACL-R have larger angles than ACL-PT. Nor were there any differences when comparing angles for the non-injured leg for the ACL-injured and the angles for the legs of the controls.

DISCUSSION & CONCLUSIONS

Subjects with ACL-injury still show reduced jump capacity in terms of distance in their injured leg about 20 years after injury. In contrast, for the non-injured leg the jump capacity is in parity with that of healthy controls. However, this was not reflected by differences in the kinematic maximum angles of the hip, knee and ankle between injured and non-injured leg for the ACL-groups, which indicates that other parameters than maximal angles taken before jump-off and after landing may be more important to investigate when describing the movement pattern after ACL-injury. Significant differences in knee and hip angles between the two ACL-groups, may indicate different movement pattern depending on treatment approach. Further kinematic analyses are under way to explore the kinematic details of the jump which is needed to quantify the movement patterns after ACL-injury in the long term perspective.

REFERENCES

.

THE ROLE OF THE INTACT LIMB IN THE ADAPTATION OF TRANSTIBIAL AMPUTEE OBSTACLE CROSSING FOLLOWING REHABILITATION

Cleveland T Barnett[1], Natalie Vanicek[2] and Remco CJ Polman[3]

[1]Nottingham Trent University, SHAPE Research Group, School of Science and Technology, Nottingham, UK
[2]University of Sydney, Discipline of Exercise and Sport Science, Faculty of Health Sciences, Sydney, Australia
[3]Victoria University, Institute of Sport, Exercise and Active Living, Melbourne, Australia

INTRODUCTION

Obstacle crossing is a complex motor skill necessary to avoid tripping or falling. Understanding how recent lower limb amputees adapt to crossing obstacles could have important implications for amputees and therapists involved in rehabilitation. Previous research has not investigated the re-learning process that occurs following discharge from rehabilitation as amputees adapt to new biomechanical constraints [1-2]. The aim of the current study was to investigate the longitudinal biomechanical adaptations in transtibial amputee obstacle crossing following discharge from rehabilitation.

PATIENTS/MATERIALS and METHODS

Seven participants (age 56.1±14.9 years, height 1.82±0.08m, mass 91.7±11.4kg) attended standardised data collection sessions at one, three and six months following discharge from rehabilitation. Reflective markers were attached to the lower limb according to the six degrees of freedom marker model set. Participants crossed an obstacle (0.1m by 1.0m) whilst walking along an eight-metre walkway at a self selected velocity. Lower limb kinematic (100Hz) and kinetic (1000Hz) data were processed and modelled in Visual 3D (C-Motion, Inc, Germantown, US) with variables normalised to the gait cycle. Self selected lead limb preference was noted during each trial. Group mean data were analysed using a linear mixed model (SPSS Inc., Chicago, USA).

RESULTS

Participants walking velocity increased by 0.17 $m.s^{-1}$ between one and six months post-discharge, regardless of lead limb preference. There was a general bias towards adopting the intact limb as the lead limb which reduced over time. Peak knee flexion during swing phase and subsequent loading response ($p=0.04$) were increased when leading with the intact limb ($p=0.03$). When leading with the intact limb, peak knee power absorption during late stance (K3) ($p=0.05$) and during swing (K4) ($p=0.01$) were significantly higher. The concentric power generation during late stance at the hip (H3) was significantly increased when leading with the intact limb ($p=0.05$). Peak knee power absorption during loading response (K1) ($p=0.04$) and peak power generation (K2) ($p=0.02$) were greater when trailing with the intact limb. Peak power absorption (K4) was greater when trailing with the intact limb when compared to the affected limb ($p=0.01$).

DISCUSSION & CONCLUSIONS

Transtibial amputees were able to negotiate obstacles effectively and tended to lead with the intact limb. Although the selection of a lead limb preference may be due to the increased ability to 'push off' at the end of the preceding stance phase [1], results from the current study suggest that the role of the intact limb having crossed the obstacle is also important. Results indicated that participants may have selected a lead limb preference for two reasons. Firstly, the greater control possible when crossing the obstacle reflected in joint kinematics. Secondly, the ability to maintain relatively high joint moments and generate and absorb power in the stance phase limb during the subsequent stance phase following obstacle crossing. Increasing affected limb hip flexor and knee extensor function may improve an amputee's ability to cross obstacles when leading with the affected limb. This may also reduce the lead limb bias observed in the current study and increase amputees' ability to avoid unexpected obstacles and subsequent falls.

REFERENCES

[1] Hill SW et al. Gait Posture 1997; 6; 186-192.
[2] Vrieling AH et al. Clin Rehabil 2009; 23; 659-671.

GAIT STRATEGIES OF TRANSFEMORAL AMPUTEES DESCENDING SLOPES

Daniel W.W. Heitzmann[1], Merkur Alimusaj[1], Julia Block[1], Thomas Dreher[1], Frank Braatz[1] and Sebastian I. Wolf[1]

[1]Heidelberg University Clinics, Department of Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

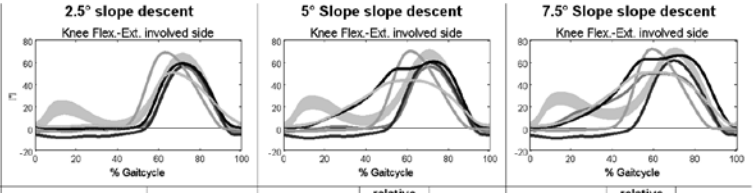
Current hydraulic and microprocessor controlled prosthetic knee joints for trans-femoral amputees (TFA) enable the user to flex the prosthetic knee throughout weight bearing of the prosthetic limb. TFA are able to use this functionality while alternate walking down stairs or descending inclines [1]. However, clinical practice shows that not all TFA use this so called “stance phase flexion” on slopes, especially on inclines with a moderate angle. This study investigates variations in gait strategy of TFA while walking down slopes.

PATIENTS/MATERIALS and METHODS

Five male TFA (48.6y ± 12.9y / 99.5kg ± 20.3kg / 1.77m ± 0.06m) were fitted with a microprocessor controlled prosthetic knee (Rheo Knee II™) and a common prosthetic foot (Variflex EVO™ / all parts Ossur, Reykjavik, Iceland). TFA underwent a conventional clinical gait analysis while walking down slopes of 2.5°, 5° and 7.5°. TFA walked at self selected speed and with their preferred strategy. For reference purpose, eleven healthy subjects (NORM / 3 female; 8 male / 29.6y ± 4.6y / 74.4kg ± 13.8kg / 180.7cm ± 7.8cm) finished the same protocol.

RESULTS

Prosthetic knee kinematics show that the five TFA have adopted two different strategies for walking down the slopes of 5° and 7.5°: 1) to bend the prosthetic knee in stance 2) to keep the prosthetic knee in stance extended. On the shallow 2.5° slope none of the TFA tends to bend the prosthetic knee in stance. In general TFA slow down on the steeper slopes.



TFA	Speed [m/s]	Strategy	Speed [m/s]	relative speed	Strategy	Speed [m/s]	relative speed	Strategy
53171	1.28	2	1.31	▲	2	1.13	▼	2
53172	1.62	2	1.67	▲	2	1.70	▲	2
52643	1.41	2	1.59	▲	2	1.47	▼	1
53189	1.49	2	1.20	▼	1	1.11	▼	1
53194	1.02	2	0.68	▼	1	0.65	▼	1
Mean TFA	1.37 ± (0.23)		1.29 ± (0.39)	▼		1.21 ± (0.40)	▼	
Mean Norm	1.47± (0.14)		1.53± (0.13)	▲		1.54± (0.16)	▲	

▼ = lower speed in relation to previous ramp / ▲ = higher speed in relation to previous ramp
strategies: 1) bend the prosthetic knee in stance 2) to keep the prosthetic knee in stance extended

Figure 1: Gait Speed and prosthetic knee kinematics of TFA descending different slopes

DISCUSSION & CONCLUSIONS

For the shallow 2.5° slope none of the TFA uses stance phase flexion of the prosthetic knee. For steep slopes this strategy seems to be favorable, possibly for a better control of gait speed. Noticeably, all TFA slow down when they switch from strategy 2 to 1. However, not all users change their strategy. This might be due to individual preferences. Further, the length of the incline, technical properties of the knee and the alignment of the prosthesis may influence this choice of strategy.

REFERENCES

[1] M. Bellmann et al., Arch Phys Med Rehabil 91 (2010), pp.644-652.

10.00 - 10.30	**COFFEE IN THE EXHIBITION HALL**
10.30 - 12.00	**SESSION 5a (A2)** **Upper extremity** **Chairmen: Eva Pontén, Ellen Jaspers**
O44 Assi, Ayman	Kinematics of upper limbs in adults: database and repeatability study for anatomical and functional movements
O45 Barton, Gabor	Correlation of the Movement Deviation Profile of shoulder muscle EMG with measures of shoulder function
O46 Bonnefoy-Mazure, Alice	Quantification of upper limb movements during gait in Hereditary Spastic Paraplegia patients and Spastic Diplegia patients
O47 Lucareli, Paulo	3D quantitative analysis of upper limb movements by using weight bracelets in adults with dyskinetic Cerebral Palsy
O48 de Bruin, Marije	Functional reach-to-grasp and muscle activation patterns before and after upper extremity surgery in patients with Cerebral Palsy
O49 van den Noort, Josien	Reliability of 3D measurement of scapular kinematics with a wireless inertial and magnetic measurement system for clinical assessment of Scapular Dyskinesis: preliminary results

O50 De Baets, Liesbet	Reliability of a three-dimensional bilateral scapular movement analysis in stroke patients
O51 Maier, Michael	Can hemi shoulder arthroplasty restore the normal range of motion in activities of daily living in patients with degenerative osteoarthritis of the glenohumeral joint? A prospective 3D video motion analysis study.
O52 Evertsson, Björn	The correlation between viscosity, elasticity and the cross-sectional area of wrist- and finger-flexor muscles – a Study of the NeuroFlexor®
10.30 - 12.00	**SESSION 5b (C4)** **Foot** **Chairmen: Tim Theologis, Sebastian Wolff**
O53 Stief, Felix	A comparative evaluation of the aofas ankle-hindfoot scale and the foot function index using the Oxford foot model
O54 Boehm, Harald	Effect of walking speed on foot kinematics determined by the Oxford Foot Model
O55 Adward Min Hyun, Paik	Definition of the Hindfoot Segment Axes in Oxford Foot Model
O56 Hösl, Matthias	Does excessive flatfoot deformity affect function? A comparison between symptomatic and asymptomatic pediatric flatfeet using the Oxford Foot Model

O57 Kranzl, Andreas	Gait analysis of Children with Clubfoot treated with the Ponseti Method
O58 Stebbins, Julie	Relationship between plantar pressure and perceived quality of life in Clubfoot
O59 Athanatos, Lambros	The role of Pedobarographic assessment of Flatfoot and its place as an outcome measure
O60 Kerr, Catriona	Marker-based foot posture assessment in children
O61 Wyss, Christian	Validation of a FE-foot model with a dummy model

KINEMATICS OF UPPER LIMBS IN ADULTS: DATABASE AND REPEATABILITY STUDY FOR ANATOMICAL AND FUNCTIONAL MOVEMENTS

Ayman Assi[1, 2, 3, 4, 5], Mohamad Karam[3], Abir Massaad[4], Wafa Skalli[5], Ismat Ghanem[2, 4, 6]

[1]University of Saint-Joseph, Pole Technologie Sante , Beirut, Lebanon
[2]University of Saint-Joseph, Faculty of Medicine, Beirut, Liban
[3]University of Saint-Joseph, Institute of Physiotherapy, Beirut, Lebanon
[4]SESOBEL, Gait lab, Beirut, Lebanon
[5]Arts et Metiers ParisTech, Laboratory of Biomechanics, Paris, France
[6]Hotel Dieu de France Hospital, Beirut, Lebanon

INTRODUCTION

Upper limbs (UL) kinematics have been widely studied in healthy and hemiplegic children during functional movements [1,2,3]. Few studies in the literature have treated UL kinematics in adults or anatomical movements. The aim of this study is to set a protocol and to create a database for UL kinematics in adults for anatomical and functional movements. The repeatability of the protocol was evaluated.

PATIENTS/MATERIALS and METHODS

Thirty asymptomatic adults (12 M, 13 F) with an average age of 29 years (SD=7,6) have formed our database. Markers placement on the upper limbs and trunk was based on the International society of Biomechanics (ISB) protocol [3]. Clusters were fixed on the humerus and forearm. Six cameras Vicon MX3 (200Hz) were used for data acquisition. Anatomical movements were acquired for left and right upper limbs: shoulder circumduction, shoulder: flex/extension, abduction, int/external rotation, horizontal ab/adduction, and elbow: flex/extension, wrist: pron/supination. A table was used to register functional movements (inspired by the Melbourne test): combing hair, reaching a target (placed at the level of face height), bring a cup to mouth, move an object form right to left. Each movement was repeated 3 times for each side. Both Euler (YXY) and Cardan (YXZ) sequences were used in the calculation of the shoulder angles [4]. The center of the gleno-humeral joint is the center of a sphere defined by the functional movements of the shoulder [5]. A repeatability study was conducted on 12 asymptomatic adults who passed the exam twice at one week interval. Angles in the 3 planes were calculated for the thorax, scapula (scapulo-thoracic), shoulder (humero-thoracic), elbow (radio-humeral) and wrist (carpo-radial). Range of Motion (ROM) was calculated for each angle. Differences in movements between dominant and non-dominant sides were evaluated.

RESULTS

Euler sequence presented a large number of gimbal lock values for shoulder angles especially for the plane of elevation. Corridors of normality were defined (mean ± 1SD). The repeatability study showed no statistical difference between sessions (t-test, $p>0,05$). The Confidence Interval (CI) at 95% was estimated for each angle. It reached a maximum of ±20° and ±23° for shoulder's flex/extension and abduction movements. There were no statistical difference between the dominant and non dominant sides during movements ($p>0,05$) except for lateral/medial rotation of the scapula during horizontal add/abduction and the add/abduction of the shoulder during lateral movement of an object.

DISCUSSION & CONCLUSIONS

Cardan sequence (YXZ) seemed to be more suitable for interpretation of shoulder angles. The CI at 95% will be taken into consideration when patient's kinematics is compared to the asymptomatic database. The maximum of test-retest variability was present where large ROM is executed (210° and 115° for shoulder flex/extension and abduction movements).

REFERENCES

[1] Jaspers, Gait Posture, 2009. [2] Butler, Gait Posture, 2010. [3] Wu, J Biomech, 2005. [4] Senk, Clin Biomech, 2006. [5] Stokdijk, J of Biomech, 2005.

CORRELATION OF THE MOVEMENT DEVIATION PROFILE OF SHOULDER MUSCLE EMG WITH MEASURES OF SHOULDER FUNCTION

Gabor J Barton[1], David H Hawkes[2], Omid Alizadehkhaiyat[2], Anthony J Howard[2], Margaret M Roebuck[2], Anthony C Fisher[3], Simon P Frostick[2], Mark A Robinson[1] and Malcolm B Hawken[1]

[1]Liverpool John Moores University, Research Institute for Sport and Exercise Sciences, Liverpool, UK
[2]University of Liverpool, Musculoskeletal Science Research Group, Liverpool, UK
[3]Royal Liverpool University Hospital, Department of Medical Physics and Clinical Engineering, Liverpool, UK

INTRODUCTION

The Movement Deviation Profile (MDP) describes an individual's deviation from normality at all points in a movement cycle. Although described and validated with joint kinematics, it can be applied to any multi-channel time varying signals [1]. The application of the MDP to evaluate electromyography (EMG) during activities of daily living may offer a simple and objective tool to aid clinical decision making. The aim of this study was to correlate the MDP derived from shoulder muscle EMG with measures of functional status in a population of rotator cuff tear patients[2].

PATIENTS/MATERIALS and METHODS

EMG was recorded from 13 shoulder muscles in a group of 13 healthy controls and 11 patients with a two tendon rotator cuff tear (RCT)[2] while performing 10 cycles of a functional shelf lifting task. Signals were filtered, rectified and smoothed; time and amplitude normalisation enabled averaging[2]. The MDP was calculated using a downloadable computer program which is based on a self-organising neural network[1]. Pearson's correlation coefficient (PCC) was used to correlate the mean MDP (a single number summary of the MDP) to functional upper limb measures. These included the Functional Impairment Test-Hand, Neck, Shoulder and Arm (FIT-HaNSA)[3], range of motion (flexion and abduction ROM), Upper Limb Function Index, Oxford Shoulder Score and mean grip strength.

RESULTS

With the exception of a moderate correlation with the Upper Limb Functional Index (PCC=-0.612, p=0.045) there were no significant correlations between the mean MDP and the functional measures: FIT-HaNSA PCC=-0.085 (p=0.804); abduction ROM PCC=-0.098, (p=0.775); flexion ROM PCC=-0.053, (p=0.878); Oxford Shoulder Score PCC=0.527, (p=0.096); mean grip strength PCC=0.205, (p=0.545).

DISCUSSION & CONCLUSIONS

The mean MDP provides an objective measure of a patient's EMG deviation from normality, but it does not correlate well with common functional measures used to assess the shoulder. This is in contrast to the high correlation of the mean MDP with functional status in gait analysis[1]. Compensation capacity of highly redundant muscle function around the shoulder may result in altered muscle activation patterns even though the functional scores remain unchanged[2]. Systematic evaluation of the time course of the MDP may highlight compensatory mechanisms employed by patients with rotator cuff tears. The MDP provides a complementary measure of movement performance with a specific focus on inter-muscular relationships around the shoulder and is therefore a valuable adjunct to guide EMG analysis.

REFERENCES

1. Barton GJ et al. (2012) Hum. Mov. Sci. doi: 10.1016/j.humov.2010.06.003.
2. Hawkes DH et al. (2011) J. Orth. Res. doi: 10.1002/jor.22051.
3. MacDermid JC et al. (2007) BMC Musculoskelet. Disord. 8:42.

QUANTIFICATION OF UPPER LIMB MOVEMENTS DURING GAIT IN HEREDITARY SPASTIC PARAPLEGIA PATIENTS AND SPASTIC DIPLEGIA PATIENTS

Alice Bonnefoy-Mazure[1], Katia Turcot[1], André Kaelin[2], Geraldo De Coulon[2] and Stéphane Armand[1]

[1]Geneva University Hospitals and Geneva University, Willy Taillard Laboratory of Kinesiology, Geneva, Switzerland
[2]Geneva University Hospitals and Geneva University, Pediatric Orthopaedic Service, Department of Child and Adolescent, Geneva, Switzerland

INTRODUCTION

Clinical resemblance of Hereditary Spastic Paraplegia (HSP) subjects and Spastic Diplegia (SD) subjects is reflected on the strong similarity of gait patterns found using a Clinical Gait Analysis (CGA). However, the motor limitations between HSP and SD are not the same [1, 2, 3]. Fewer studies focused on the upper limbs kinematic concerning these two populations [1, 2, 3]. Thus, the aim of this study was to analyze the upper limb movements in HSP and SD patients during the gait.

PATIENTS/MATERIALS and METHODS

11HSP patients (5 males and 6 females, age: 16.7 ± 5.8 years) and 10 SD patients (6 males and 4 females, age: 12.3 ± 4.5 years) have been evaluated with a CGA between 2000 and 2011 (VICON 460 and Mx3+; ViconPeak® Oxford, UK). Reflective markers were placed at defined anatomical points on the upper limbs, trunk, pelvis and lower limbs. The kinematic parameters were computed using the ViconPeak® software (Plug-In-Gait). For the two groups, the elbow flexion and the shoulder elevation have been calculated (range of motion (ROM), mean, maximum, minimum values). The angles were expressed in degrees (°). In addition, the mean amplitude of the normalized (by the patient's height) arm swing lengths have been calculated [4]. All patients were asked to walk at their self-selected speed along a 10-meter walkway. The mean kinematic parameters for the two populations have been analyzed with a Mann-Whitney comparison test. A significant *p*-value was set at 0.05.

RESULTS

Significant differences were obtained. HSP group has a lower shoulder elevation for the mean (mean ± std; HSP: 29.8 ± 10.1° versus SD: 37.8 ± 8.3°) and for the peak angle (mean ± std; HSP: 37.7 ± 12.6° versus SD: 47.2 ± 7.8°). HSP group has a lower elbow flexion for the mean (mean ± std; HSP: 34.3 ± 14.1° versus SD: 67.9 ± 26.7°), for the peak angle (mean ± std; HSP: 50.6 ± 18.2° versus SD: 78.3 ± 23.8°) and for the minimum angle (mean ± std; HSP: 21.0 ± 12.5° versus SD: 57.0 ± 29.7°). SD group has a significant longer arm swing length (mean ± std; SD: 0.7± 0.1 versus HSP: 0.61 ± 0.1), a larger arm swing length (mean ± std; SD: 0.11± 0.04 versus HSP: 0.07 ± 0.02) and a higher arm swing length (mean ± std; SD: 0.14± 0.06 versus HSP: 0.09 ± 0.04).

DISCUSSION & CONCLUSIONS

The SD patients showed a more elevation in the shoulders with an increased elbow flexion compared to HSP patients. Thus, the SD patients kept their arms outward in order to gain stability and balance during their gait. Movements of the upper limbs are used as compensation for gait deviation and to fine-tuning of balance control. Moreover, SD patients have largest arm movements in the sagittal, frontal and transversal planes [4]. During human walking, the arms normally swing in opposition to the legs, which help balance angular momentum generated in the lower body [5]. Thus the arm motion during the gait could be a pertinent parameter in order to study the gait of patients with disorder of posture and motor impairment.

REFERENCES

1 Cimolin, V., et al. 2007. Funct. Neurol 22(1), 23-28. 2 Piccinini, L., et al. 2010. Europ J. Paediatr Neur, 15, 138-145. 3 Wolf, S., et al. 2011. Gait Posture 33, 556-561. 4 Meyns, P., et al. 2011. Res Develop Dis 32, 1957-1964. 5 Park, J. 2008. J.Biomech 41, 1417-1426.

3-D QUANTITATIVE ANALYSIS OF UPPER LIMB MOVEMENTS BY USING WEIGHT BRACELETS IN ADULTS WITH DYSKINETIC CEREBRAL PALSY

Paulo RG Lucareli[1], Mariana Artilheiro[1], Veronica Cimolin[2], Manuela Galli[2], Silvio A Garbelotti[1] and João CF Correa[1]

[1]Nove de Julho University, Human Motion Analysis Laboratory, São Paulo, Brazil
[2]Politecnico di Milano, Department of Bioengineering, Milan, Italy

INTRODUCTION

The presence of involuntary movements, difficulty in maintaining linear trajectory and the high variability of movements found in Dyskinetic Cerebral Palsy (DCP) may affect the execution of upper limb functional tasks.(1) The aim of this study was to assess quantitatively the effect of the application of a load using weight bracelets, on linear parameters of upper limb movement of DCP.

PATIENTS/MATERIALS and METHODS

Sixteen adults with DCP (29.63±4.42years) were asked to perform six consecutive movements bringing a mug (350 ml) with 50% of total volume to the mouth using their dominant side. The mug was placed at 75% of subjects' maximum reach. We used a dynamometer to estimate the maximal strength and to select the percentage of load used. Six repetitions of each of the following five conditions were performed: initial condition without load; final condition without load; three intermediate conditions, with 10%, 20%, 30 % of maximal load in random sequence. Kinematic data was captured by nine cameras (Vicon® MX 40; Oxford Metrics Group, Oxford, UK) with twenty passive markers placed over specific points on the head, trunk and upper extremities.(2). From the 3D coordinates of each markers, using a dedicated software (SMART Analyser; BTS spa, Milan, Italy), some parameters were identified and calculated for each movement and each participant. In particular we computed the movement duration (time to perform the movement phases and going/return ratio), representative indices of the movement smoothness (index of curvature, number of movement units and jerk) and velocity (average velocity, peak velocity and time to peak velocity).

The one-way ANOVA was used to compare the five conditions of load; Post-hoc test comparison (Least Square Difference) was applied to identify what, or which, loads differ ($p \leq 0.05$).

RESULTS

Our data showed that the only parameter significant to differentiate the conditions of movement execution was the application of load of 10%: its application resulted in time decreasing to perform going phase. The other parameters were not affected by application of loads from a statistical point of view.

DISCUSSION & CONCLUSIONS

Our results showed that the movement was neither influenced by the velocity and smoothness parameters nor by the adjusting and returning phases of time parameters. The movement with load appeared to be similar to the movement without load, and it may indicate that the movement performance of patients with DCP was not influenced by application of loads.

REFERENCES

[1] Sanger TD. Arm trajectories in Dyskinetic Cerebral Palsy have increased random variability. J Child Neurol. 2006; 21: 551-57.

[2] Rab G, Petuskey K, Bagley A. A method for determination of upper extremity kinematics. Gait Posture. 2002; 15: 113-119.

FUNCTIONAL REACH-TO-GRASP AND MUSCLE ACTIVATION PATTERNS BEFORE AND AFTER UPPER EXTREMITY SURGERY IN PATIENTS WITH CEREBRAL PALSY

Marije De Bruin[1], DirkJan Veeger[2], Michiel Kreulen[3], Mark JC Smeulders[1] and Sicco A Bus[4]

[1]Academic Medical Center, Department of Plastic, Reconstructive and Hand Surgery, Amsterdam, The Netherlands
[2]VU University, Research Institute MOVE, Faculty of Human Movement Sciences, Amsterdam, The Netherlands
[3]Red Cross Hospital, Department of Plastic, Reconstructive and Hand Surgery, Beverwijk, The Netherlands
[4]Academic Medical Center, Human Performance Laboratory, Department of Rehabilitation Medicine, Amsterdam, The Netherlands

INTRODUCTION

Patients with spastic cerebral palsy (CP) may suffer from spasticity in the upper extremity, resulting in decreased range of motion (ROM) and typical joint postures (i.e. extreme wrist flexion and inability to supinate). Although changes in joint position and ROM are reported after surgery, the gained ROM is not necessarily employed during the performance of functional tasks. However, surgical release procedures do seem to facilitate a more natural movement pattern [1]. Increased coactivation is one of the deficits associated with the typical awkward movement patterns in CP [i.e. 2]. We aimed to describe the changes in muscle activation and movement strategy during functional tasks as a result of forearm tendon transfer surgery. We hypothesized that surgery results in a change in activation of biceps and triceps, which would lead to normalization of elbow extension and forearm supination at endpoint of reach-to-grasp.

PATIENTS/MATERIALS and METHODS

Pre- and 9 months post-surgery, CP patients (n=12; mean age 14 years) performed unconstrained maximal isolated ROM of forearm and elbow and functional reach-to-grasp tasks that provoke elbow extension and pronation (picking up a disk) or supination (picking up a glass). All patients had multiple surgical procedures on tendons primarily affecting hand, wrist and forearm, aimed at functional improvement of the spastic upper extremity. Objects were placed at 1.5 forearm's length in front of the subject. 3D upper limb kinematics was assessed using an 8-camera Vicon MX system. EMG signals of biceps and triceps of the affected arm were measured during both tasks using a Noraxon Telemyo 2400R system following SENIAM guidelines [3]. Rectified and smoothed signals were normalized to maximal voluntary contraction (MVC). Biceps-triceps coactivation was determined as the amount of overlap of the activation of both muscles. Endpoint of reach-to-grasp was determined using the Multiple Sources of Information Method [4]. Angles and EMG-activation at endpoint of reach-to-grasp before and after surgery were compared using ANOVA for repeated measures.

RESULTS

Patients showed more elbow extension at endpoint of reach-to-grasp on both tasks (P<0.01). Maximal isolated supination angle increased with an average of 16 degrees but there was no significant effect on the maximal isolated ROM of both forearm and elbow (P>0.05). Furthermore, forearm rotation did not shift towards supination at endpoint of reach-to-grasp of the glass as a result of surgery (P>0.05). Biceps-triceps coactivation did not change as a result of surgery (P>0.05).

DISCUSSION & CONCLUSIONS

Although there does not seem to be a significant decrease of biceps-triceps coactivation after surgery, patients performed both functional tasks with a more extended elbow angle at endpoint of reach-to-grasp. Apparently, surgery performed on the forearm and wrist of CP patients has an effect on functional performance of the elbow. Consequently, preoperative diagnosed functional decreased elbow flexion does not necessarily demand treatment of the elbow flexors.

REFERENCES

[1] Kreulen et al. *Gait Posture*; **25**(3):485-492, 2007.

[2] Braendvik & Roeleveld. *JEK*; **22**:137-144, 2011.

[3] Hermens et al. Roessingh Research and Development, Enschede, The Netherlands, 1999.

[4] Schot WD et al. *J Neurosci Methods*; **187**:147-155, 2010.

RELIABILITY OF 3D MEASUREMENT OF SCAPULAR KINEMATICS WITH A WIRELESS INERTIAL AND MAGNETIC MEASUREMENT SYSTEM FOR CLINICAL ASSESSMENT OF SCAPULAR DYSKINESIS: PRELIMINARY RESULTS

Josien C Van den Noort[1], Suzanne H Wiertsema[1], Karin MC Hekman[1], Casper Schonhuth[2], Joost Dekker[1] and Jaap Harlaar[1]

[1]VU University Medical Center, Rehabilitation Medicine, Amsterdam, Netherlands
[2]VU University Medical Center, Orthopaedics, Amsterdam, Netherlands

INTRODUCTION

The scapula plays an important role in shoulder function. In people with shoulder pathologies, alterations in scapular position and motion (scapular dyskinesis) have been observed [1]. To direct interventions aimed at improving scapular position, motion, and muscle force, objective and reliable measurement of scapular dyskinesis in clinical setting is important. Currently used measures are not reliable or objective, clinically not suitable, static or invasive (e.g. visual based scapular dyskinesis tests, optoelectronic markers, scapula locators or bonepins). An inertial and magnetic measurement system (IMMS: small, wireless sensors containing gyroscopes, accelerometers, and magnetometers) could be a good alternative to measure scapular motion in clinical routine [2]. The aim of this study is to evaluate the intra- and inter-observer reliability and the validity of the IMMS for measurement of scapular motion in 20 healthy subjects and in 20 patients with shoulder pathology and suspicion of scapular dyskinesis.

PATIENTS/MATERIALS and METHODS

So far, six healthy subjects without shoulder problems participated in the reliability study (age 29±3, BMI 22±2). For intra-observer reliability, the scapular motion was measured with the IMMS by the same physical therapist on two different days (T0 and T1). For inter-observer reliability, at T1 a second physical therapist also measured the scapular motion with the IMMS. Four IMMS sensors were placed on the scapula (edge of spina), thorax, upper and lower arm. The subjects repeatedly elevated their arm in the sagittal plane (anteflexion) and in the frontal plane (ab/adduction) (3 trials with 3 repetitions per plane). 3D kinematics of the scapula with respect to the thorax were measured. Reliability was assessed according to the Generalizability Theory, using variance components to calculate the intraclass correlation coefficients (ICC), the standard error of measurement (SEM) and the smallest detectable change (SDC) [3]. Here we present the results of scapular upward rotation (frontal plane) during dynamic anteflexion (reliability measured at 0, 30, 60, 90 and 120 deg anteflexion).

RESULTS

Intra-observer reliability for scapular upward rotation during anteflexion ranges from ICC 0.66-0.95, SEM 3-4 deg, SDC 9-12 deg. Inter-observer reliability ranges from ICC 0.80-0.98, SEM 2-3 deg, SDC 6-9 deg.

DISCUSSION & CONCLUSIONS

Reliability of IMMS for scapular upward rotation during anteflexion is high. Remarkably, inter-observer reliability is higher than intra-observer reliability. This may be due to the fact that one subject showed relatively high intra-observer differences (10-14 deg), which is influencing the results substantially since only six subjects are included. In the near future, more subjects will be included and the reliability and the validity of the complete 3D dynamic movements of the scapula during anteflexion and ab/adduction will be analysed. If also a high reliability as well as a high validity of the IMMS in other planes of movement are found, the IMMS is well suitable for application in clinical routine since sensors are wireless, small and easy to use, and scapular dyskinesis can be measured objectively during dynamic tasks.

REFERENCES

[1] Warner et al., Clinical Orthopaedics and Related Research 285 (1992) 191-199

[2] Parel et al., Gait & Posture 35 (2012) 636-640

[3] de Vet et al., Journal of Clinical Epidemiology 59 (2006) 1033-1039

RELIABILITY OF A THREE-DIMENSIONAL BILATERAL SCAPULAR MOVEMENT ANALYSIS IN STROKE PATIENTS

Liesbet De Baets[1, 2], Ellen Jaspers[3], Kaat Desloovere[3, 4], Sara Van Deun[1]

[1]PHL University College, REVAL Rehabilitation Research Center, Hasselt, Belgium
[2]Hasselt University, BIOMED Biomedical Research Institute, Hasselt, Belgium
[3]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[4]University Hospital, Clinical Motion Analysis Laboratory, Pellenberg, Belgium

INTRODUCTION

Scapular movement with respect to the thorax is described in three rotations during humerothoracic elevation. In order to assess this three-dimensional (3D) character of movement, a 3D movement analysis seems most appropriate. This study wants to determine the reliability of the 3D scapulothoracic movement pattern in stroke patients.

PATIENTS/MATERIALS and METHODS

10 stroke patients were tested twice, with a time interval of 5 to 8 days. Scapular motion was assessed during bilateral frontal (EF) and sagittal (ES) plane elevation (0-60°, 0-120°). Three trials of four repetitions were captured for every elevation task. Retroreflective markers were placed on the trunk, and on the scapula and humerus of the hemiplegic (HS) and non-hemiplegic (NHS) side. Scapular bony landmarks were palpated and digitized during static trials (CAST-method) [1]. Anatomical coordinate systems and joint rotation sequences were defined following the ISB [2]. Marker tracking was done with 15 Vicon-cameras (Oxford Metrics, UK). For further data processing, BodyMech (MOVE, Amsterdam) and Matlab were used. The second and third repetition of every trial was statistically analyzed, using the coefficient of multiple correlation (CMC) to investigate the similarity of angular waveforms [3].

RESULTS

0°-120°: *Within session reliability* was excellent (>0.90) for all scapular rotations during EF and ES (HS and NHS). *Between sessions reliability* was excellent for scapular lateral rotation for both tasks, on both sides. ES resulted in good (0.80-0.89) to excellent reliability for protraction and scapular tilt (both sides). For EF, protraction was only poorly (<0.60) reliable (HS and NHS), while scapular tilt was moderately (0.60-0.79) reliable (HS and NHS). 0°-60°: *Within session reliability* was excellent for all scapular rotations during EF, and good to excellent during ES. *Between sessions* lateral rotation during EF and ES, and protraction during ES showed good reliability, while protraction (EF) and scapular tilt (EF and ES) were poorly reliable.

DISCUSSION & CONCLUSIONS

Standardization should be optimized to maximize between session reliability as low CMCs for tilting and scapular protraction/retraction were found. Since reliability also seemed to depend on the selected task, the reliability of additional tasks should also be explored. Such task selection should be based on movements of interest in clinical practice.

REFERENCES

[1] Cappozzo et al. (1995), Clin Biomech 10(4):171-178

[2] Wu et al. (2005), J Biomech 38(5):981-992

[3] Kadaba M.P. et al. (1989), J Orthop Res 7(6):849-860

CAN HEMI SHOULDER ARTHROPLASTY RESTORE THE NORMAL RANGE OF MOTION IN ACTIVITIES OF DAILY LIVING IN PATIENTS WITH DEGENERATIVE OSTEOARTHRITIS OF THE GLENOHUMERAL JOINT? A PROSPECTIVE 3 D VIDEO MOTION ANALYSIS STUDY.

Michael W. Maier[1], Mirjam Niklasch[1], Thomas Dreher[1], Felix Zeifang[1], Oliver Rettig[1], Sebastian I. Wolf[1] and Philip Kasten[2]

[1]University of Heidelberg, Department of Orthopedics and Trauma Surgery, Heidelberg , Germany
[2]Carl-Gustav Carus University, Department of Orthopedics and Trauma Surgery, Dresden, Germany

INTRODUCTION

Hemi shoulder arthroplasty can improve the function of osteoarthritic shoulders, but the ability to perform activities of daily living (ADL) can still remain impaired. Routinely, shoulder surgeons measure parameters like range of motion, pain, satisfaction and strength. A common subjective assessment of ADL is a part of the Constant score (CS). But there is limited objective data weather hemi shoulder arthroplasty can restore the normal range of motion (ROM) in ADL.

PATIENTS/MATERIALS and METHODS

This study included eight consecutive patients (7 women, 1 man) who received hemi shoulder arthroplasty (HEP) (n=8) for shoulder osteoarthritis. The patients were examined the day before, 6 months after and three years after shoulder replacement. We compared them with a control group without any shoulder pathology and measured shoulder movement with a 3 D motion analysis using the Heidelberg Upper Extremity model (HUX) 1. The measurement included 4 activities of daily living.

RESULTS

Comparing the preoperative to the three years postoperative ROM in the flexion/ extension plane ROM improved from 127.4° [SD ±51.3°] to 214.6° [SD ±70.5°] p=0.063, in comparison, the controls achieved 256.5° [SD ±78.0°]. In the ab-/ adduction plane ROM improved from preoperative 59.3° [SD ±21.7°] to postoperative 147.3° [SD ±19.8°] p=0.031, compared to 218.3° [SD ±82.7°] of the controls.

DISCUSSION & CONCLUSIONS

In patients with glenohumeral osteoarthritis, hemi shoulder arthroplasty improves the ROM in ADL three years after surgery, but compared to the controls it can not restore the full range of motion in all planes. 3 D motion analysis with the HUX is an appropriate measurement system to detect surgery dependent changes in shoulder arthoplasty.

REFERENCES

1. Rettig, O., et al., *A new kinematic model of the upper extremity based on functional joint parameter determination for shoulder and elbow.* Gait Posture, 2009. **30**(4): p. 469-76.

THE CORRELATION BETWEEN VISCOSITY, ELASTICITY AND THE CROSS-SECTIONAL AREA OF WRIST- AND FINGER-FLEXOR MUSCLES – A STUDY OF THE NEUROFLEXOR®

Eva Pontén[1], Björn Evertsson[1] and Johan Gäverth[2]

[1]Karolinska Institutet, Dept of Pediatric Orthopaedic Surgery, Stockholm, Sweden
[2]Karolinska Institutet, Dept of Women's and Children's Health, section for Neuropediatrics, Stockholm, Sweden

INTRODUCTION

The NeuroFlexor® is an apparatus that estimates the viscosity, elasticity and the neural component of the resistance in the wrist and finger flexor muscles when the wrist is passively extended. Only the neural component has been validated, and the device has not been used in children. It is proposed that viscosity and elasticity increase with increased muscle cross-sectional area.

The aim of the study was to correlate the cross-sectional areas of wrist and finger flexor muscles with viscosity and elasticity measured with the NeuroFlexor®, and with grip strength.

PATIENTS/MATERIALS and METHODS

15 typically developed subjects, 8-18 years old and one subject with cerebral palsy (CP), 17 years old, were tested with the NeuroFlexor®. Ultrasound was used to obtain the cross-sectional areas of the flexor carpi radialis and flexor digitorum superficialis muscles. Grip strength was measured with the Grippit®.

RESULTS

There were moderate correlations between the viscosity and the cross sectional areas of the flexor carpi radialis (r_{rho} =0.57; p=0.03) and the flexor digitorum superficialis (r_{rho}=0.57; p=0.03). There were no correlations between elasticity and the flexor carpi radialis (r_{rho}=0.30; p=0.28) and flexor digitorum superficialis (r_{rho}=0.28; p=0.33).

DISCUSSION & CONCLUSIONS

The current pilot study suggests that the NeuroFlexor® estimates viscosity correctly. The NeuroFlexor® has the potential to become a useful tool for treatment evaluation in children with CP and contribute to the understanding of contractures.

REFERENCES

Lindberg PG, Gaverth J, Islam M, Fagergren A, Borg J, Forssberg H. Validation of a new biomechanical model to measure muscle tone in spastic muscles. Neurorehabil Neural Repair. 2011;25(7):617-25.

A COMPARATIVE EVALUATION OF THE AOFAS ANKLE-HINDFOOT SCALE AND THE FOOT FUNCTION INDEX USING THE OXFORD FOOT MODEL

Felix Stief[1], Tanja Kostuj[2], Kirsten Zettersten[2], Andrea Meurer[2], Mohammad Arabmotlagh[2], Klaus Schmidt[3], Frank Krummenauer[4] and Sebastian Lieske[5]

[1]Orthopaedic University Hospital Friedrichsheim gGmbH, Movement Analysis Lab, Frankfurt/Main, Germany
[2]Orthopaedic University Hospital Friedrichsheim gGmbH, Frankfurt/Main, Germany
[3]Catholic Hospital Dortmund West, Dortmund, Germany
[4]University Witten/Herdecke, Institute for Medical Biometry and Epidemiology (IMBE), Witten/Herdecke, Germany
[5]Hospital for Trauma Surgery and Orthopaedics, Magdeburg, Germany

INTRODUCTION

Several questionnaires have been developed for assessing foot pain, disability and functional limitations of patients suffering from foot and ankle pathologies. Three-dimensional gait analysis is used to objectively detect slight gait abnormalities and to evaluate patient's perception of the treatment outcome in both research and clinical practice. In order to provide optimal treatment, it would be helpful to know the association between gait abnormalities and two commonly used foot and ankle questionnaires. Therefore, the purpose of this study was to correlate dynamic foot function with the AOFAS Ankle-Hindfoot Scale and the Foot Function Index (FFI) in patients with foot and ankle pathologies. Dynamic foot function was measured using the Oxford Foot Model (OFM) [1].

PATIENTS/MATERIALS and METHODS

OFM, AOFAS scale and FFI data were consecutively collected from 20 patients with mild to severe ankle and hindfoot pathologies (arthrosis, osteochondrosis dissecans, chondromatosis of the ankle joint and ankle endoprosthesis). This heterogenic group was deliberately chosen to reflect a wide range of patients. An eight-camera Vicon system (Oxford, UK) and one force plate (AMTI, Watertown, USA) were used to collect kinematic and kinetic data during level walking at a self-selected speed. Simple linear regression (Pearson's correlation; r) was used to examine the association between the degree of gait impairment and the scores calculated using the two questionnaires. The level of significance for this study was set at $P < 0.05$. In terms of bilateral involvement, the more severely affected foot was chosen.

RESULTS

The AOFAS score shows medium to high correlations ($r = 0.41$ - 0.72) for 20 of 34 gait parameters. In contrast, there were no significant correlations between the FFI and dynamic foot function for most of the selected gait parameters (29 of 34). Moreover, spatio-temporal parameters exhibited medium to high correlations ($r = 0.46$ - 0.65) with the AOFAS score and no significant correlations with the FFI.

DISCUSSION & CONCLUSIONS

In summary, three-dimensional gait analysis can be used to evaluate patient's perception of disability. These first results suggest that the AOFAS Ankle-Hindfoot Scale shows a stronger relation to gait parameters than the FFI. In particular, the positive correlation between the AOFAS score and ankle power generation indicates that the AOFAS Ankle-Hindfoot Scale is well suited to evaluate limitations in foot function during gait. However, further biometric and epidemiological analyses are needed to strengthen this relationship.

REFERENCES

[1] Stebbins et al. (2006) Gait Posture, 23(4):401-10.

EFFECT OF WALKING SPEED ON FOOT KINEMATICS DETERMINED BY THE OXFORD FOOT MODEL

Harald Böhm[1], Falk Nestler[2], Matthias Hösl[1] and Leonhard Döderlein[1]

[1]Behandlungszentrum Aschau GmbH, Orthopaedic Hospital for Children , Aschau im Chiemgau, Germany
[2]University of Technology , Department of Preventive Pediatrics, Munich, Germany

INTRODUCTION

The motion occurring at the joints of the foot are related to the functional demands during walking. Subtalar joint pronation during loading response might be essential to dampen impact forces, whereas supination during push-off might provide a rigid lever for thrust [1]. To verify the function it is important to determine adaptive movements at increasing walking speeds. The Oxford foot model (OFM) provides information about 3D foot motion. For the clinical interpretation of the data it would be helpful to know which parameters might give the foot flexibility for shock absorption and a rigid lever for thrust. Therefore the aim was to investigate the effect of walking speed on foot kinematics.

PATIENTS/MATERIALS and METHODS

11 typically developed children 10 (SD=2) years participated in the study. They walked at slow, preferred and fast speeds. Motion was captured with the Vicon camera system using the OFM. In total 16 parameters were derived. To separate between shock damping and thrust, gait was subdivided into pronation phase (0-30 % gait cycle) and supination phase (30-70%). In pronation phase tibia to hindfoot peak plantarflexion, peak eversion and peak external rotation, forefoot to midfoot peak plantarflexion, peak pronation and peak abduction, peak hallux flexion and min. medial arch height were determined. In the supination phase it were tibia to hindfoot peak plantarflexion, peak supination and peak adduction, forefoot to midfoot peak plantarflexion, peak supination and peak adduction, peak hallux extension and max. medial arch height. Only parameters were considered for statistical analysis that showed a continuous increase or decrease with speed. ANOVA on the factor speed was performed following post-hoc tests.

RESULTS

21 legs were analysed. Significant differences in parameters between all three walking speeds were observed in the pronation phase for increasing peak hindfoot to tibia external rotation ($p<.001$). For the supination phase it were increasing peak plantarflexion of hindfoot to tibia ($p=.002$), increasing peak plantarflexion of the midfoot ($p<.001$) and increasing peak hallux dorsiflexion ($p<.001$).

DISCUSSION & CONCLUSIONS

In the pronation phase only hindfoot to tibia external rotation was significantly increased with speed. This allows the tibia to internally rotate with respect to the knee, which is a prerequisite for knee flexion [1]. Therefore hindfoot rotation indirectly allows for shock absorption, since it enabled the knee to flex and thus allowed the quadriceps musculature more time to dampen impact forces. Concerning thrust during the supination phase, the ankle joint plantar flexes more with increasing speed. This might result in greater ankle push-off power. In addition the midfoot was significantly more plantar flexed. That means that the longitudinal arch between hindfoot and midfoot was increased. The reason might be the windlass effect caused by the increased hallux flexion observed. In conclusion none of the selected parameters during pronation phase could be directly associated with dampening impact forces. However, hindfoot to tibia external rotation was indirectly allowing the knee to flex and thereby dampening impact forces. A rigid lever for thrust was obtained by the windlass effect, which was shown to increase midfoot plantarflexion with speed.

REFERENCES

[1] Michaud T.C. (1997) Foot orthoses and other forms of conservative foot care. Newton MA: 27–56

DEFINITION OF THE HINDFOOT SEGMENT AXES IN OXFORD FOOT MODEL

Adward Min Hyun Paik[1], Julie Stebbins[2], Jessica Leitch[2] and Amy B Zavatsky[1]

[1]University of Oxford, Department of Engineering Science, Oxford, United Kingdom
[2]Nuffield Orthopaedic Centre, Oxford Gait Laboratory, Oxford, United Kingdom

INTRODUCTION

The Oxford Foot Model (OFM) [1] is a multi-segment foot model, which consists of three rigid segments (tibia, hindfoot and forefoot). The segments are defined by surface markers placed on bony landmarks on the foot and leg. The accuracy of the OFM angle calculations depends on how the markers and segment axes relate to the underlying anatomy. In an attempt to clarify why there is large intra-subject variability in OFM hindfoot rotation, the hindfoot segment was chosen as the focus of this study. In the OFM, the longitudinal Antero-Posterior (A-P) axis of the hindfoot is intended to lie in the mid-sagittal plane of the calcaneus and parallel to the plantar surface of the foot. The other two hindfoot axes depend on the A-P axis definition. This study compares the marker-defined OFM hindfoot A-P axis to the plantar plane projection of the 1st principal axis of the calcaneus. Both these axes are also compared to the long axis of the foot.

PATIENTS/MATERIALS and METHODS

Twenty adult females participated in the study (40 feet). Radiopaque monitoring electrodes (Type 2223, 3M Healthcare, Neuss, Germany) were placed on the feet at the locations specified by the OFM. CT images (GE 64-slice Lightspeed VCT scanner) were acquired as the subjects lay supine. The 3-Dimensional (3D) coordinates of the electrodes and of the points corresponding to the ideal marker locations were extracted from the images. The calcanei were segmented and re-constructed to create 3D models using Mimics (Materialise NV, Leuven, Belgium). The models were exported to SolidWorks (Dassault Systèmes SolidWorks Corp., Vélizy, France) for calculation of the principal axes. The marker based OFM A-P axis which extends from the heel marker to the mid-point of medial and lateral calcaneus markers, Heel-Toe (H-T) axis which extends from the heel to the marker that is located at the mid-point of the heads of second and third metatarsals, and the 1st principal axis were calculated, and their transverse plane projections were compared.

RESULTS

The OFM A-P axis was different from both the 1st principal axis and the H-T axis in all subjects (Table 1). There was large variation, both medially and laterally, in its orientation relative to the other two axes. There was also a difference between the H-T and 1st principal axes, but the range of variation was smaller than for the A-P axis comparisons. Differences also tended to be inconsistent between left and right feet of the same subject.

Table 1: Angular differences (°) between the 1st principal axis, A-P axis and H-T axis (IQR = interquartile range)

		1st Principal vs A-P	H-T vs A-P	H-T vs 1st Principal
Right	Median	-5.0°	-8.2°	-1.3°
	IQR	18.9° (-10.7° - 8.2°)	16.1° (-12.9° - 3.2°)	5.4° (-5.5° - -0.1°)
Left	Median	-0.8°	-1.5°	-1.5°
	IQR	11.3° (-8.8° - 2.5°)	9.8° (-7.2° - 2.6°)	5.0° (-3.3° - 1.7°)

DISCUSSION & CONCLUSIONS

The differences between the A-P and the other axes are inconsistent, meaning that it is impossible to apply an offset to achieve a marker-based A-P axis that is aligned either to the long-axis of the calcaneus or the long-axis of the foot. In contrast, it is evident that the H-T axis tends to lie closer to the 1st principal axis. It should be highlighted that, while most angle output results from the OFM are reliable, caution must be used when interpreting hindfoot rotation as the marker segment definition may be inadequate to describe the actual calcaneal rotation. One possible reason for this could be misplacement of the hindfoot markers; further studies are needed to quantify the effects of this.

REFERENCES

1. Stebbins J, Harrington M, Thompson N, Zavatsky AB, Theologis T: **Repeatability of a model for measuring multi-segment foot kinematics in children**. *Gait Posture*, 2006, **23**:401-411

DOES EXCESSIVE FLATFOOT DEFORMITY AFFECT FUNCTION? A COMPARISON BETWEEN SYMPTOMATIC AND ASYMPTOMATIC PEDIATRIC FLATFEET USING THE OXFORD FOOT MODEL

Matthias Hösl[1], Harald Böhm[1] and Leonhard Döderlein[1]

[1]Behandlungszentrum Aschau GmbH, Orthopaedic Hospital for Children, Aschau im Chiemgau, Germany

INTRODUCTION

Surgery on severely deformed but painless, asymptomatic flatfeet is highly controversial [1]. While pediatric and juvenile flatfeet are rarely symptomatic, they may lead to knee pain [2] and tibial stress syndrome [3]. To understand how pathology evolves we first compared foot motion of asymptomatic and symptomatic flatfeet, hypothesizing that the latter show more excessive movement pathology. Second, the effect of flatfeet on ankle joint energy during loading response (LR) and terminal stance (TST) was investigated.

PATIENTS/MATERIALS and METHODS

21 flat-footed children (11±3 years) and 10 children with typically developed feet (TD) participated. All flatfeet were referred to the gait laboratory for clinical decision making. 14 flatfeet of 8 children caused pain (SFF), while 13 children were asymptomatic (ASFF). Tarsal coalitions were excluded. Foot kinematics were analyzed with the Oxford Foot Model. Ankle kinetics were captured with the Plug-in-Gait Model. Differences between SFF, ASFF and TD concerning rearfoot to tibia and fore to rearfoot motion in stance, as well as ankle kinetics were analyzed with ANOVA and post-hoc tests. Pearson's correlation was used to investigate the relation between foot kinematics and ankle kinetics.

RESULTS

Rearfoot eversion at IC and peak eversion during stance was significantly different between groups ($p<.001$ with ASFF > TD and SFF > TD). ASFF tended to be more everted than SFF. Fore to rearfoot supination and abduction was significantly increased (all $p<.001$). Both ASFF and SFF considerably deviated from TD (all $p<.001$), but could not be discriminated (all $p>.48$). Same holds for peak midfoot dorsiflexion. However, differences between ASFF and TD were large and significant ($p<.001$), while differences between SFF and TD were less pronounced ($p=.06$). Kinetic analysis showed that during LR, ASFF absorbed significantly more ankle joint energy (72% and 77%) than TD and SFF ($p<.02$). TD and SFF performed similar ($p=.72$). Yet, SFF significantly lacked propulsive ankle joint energy (-31%, $p=.014$) in comparison to TD, while AFF did not ($p=.64$). Rearfoot eversion at IC was significantly correlated with absorption of ankle joint energy ($r=-.36$, $p=.02$).

DISCUSSION & CONCLUSIONS

Both SFF and ASFF showed pronounced deviations from TD. We found significantly larger peak dorsiflexion between fore and rearfoot and also larger rearfoot eversion in our clinical flat-footed sample than others [4]. ASFF tended to show more excessive deviations than SFF, which contrasted our expectations. From a functional perspective, only SFF lacked propulsion. However, in ASFF absorption of ankle joint energy during LR was considerably increased. Correlational analysis revealed that excessive rearfoot eversion at IC may impair shock absorption. This risks overloading of anterior structures of the shank when lowering the foot after heel contact. In conclusion, symptoms may rather depend on other factors than on excessive movement pathology. Functional limitations may not arise before the onset of pain. Preventive indication for surgery needs careful consideration and awaits longitudinal studies to find predictors of pain.

REFERENCES

[1] Kelikian A. et al., Foot Ankle Spec 2011, 4(2): 112–119.

[2] Kosashvili Y. et al., Foot Ankle Int 2008, 29(9): 910-913.

[3] Moen M.H. et al., Scand J Med Sci Sports 2012, 22(1): 34–39.

[4] Levinger P. et al., Gait & Posture 2010, 32(4): 519–532.

GAIT ANALYSIS OF CHILDREN WITH CLUBFOOT TREATED WITH THE PONSETI METHOD

Andreas Kranzl[1], Gabriel Mindler[2], Christof Radler[2] and Franz Grill[2]

[1]Orthopaedic Hospital Speising, Vienna, Laboratory for Gait and Movement Analysis, Vienna, Austria
[2]Orthopaedic Hospital Speising, Vienna , Department of Pediatric Orthopaedics , Vienna, Austria

INTRODUCTION

The Ponseti method is a minimal-invasive clubfoot treatment with increasing utilization all over the world. However, only a view studies [1-4] used gait analysis to assess results of clubfoot treatment at the end of the bracing period. The present study used clinical examination and gait analysis in order to evaluate the midterm results of the Ponseti method. Aim of the study was to evaluate the functional outcome of this treatment option and to compare the outcome to an age matched control group.

PATIENTS/MATERIALS and METHODS

We invited patients from our prospective database for clubfeet treated with the Ponseti method with a minimum age of 3 years. Gait analysis and clinical examination were done on unilateral and bilateral affected patients. A 3D gait analysis using a Cleveland clinical marker set in combination with the Oxford foot model was performed. Kinetic and kinematic results were compared to the non-affected side of unilateral clubfoot patients. Patients with neurogenic disorders, syndrome associated clubfeet, joint invasive surgery, treatment beginning after 4 weeks of age, positional clubfoot and patients who lived outside Austria, or had initial treatment with less than 3 casts were excluded. A total of 125 patients met the inclusion criteria and were invited. A total of 32 children participated. An age matched group of 15 healthy children served as control group 5.5 years (3.3–8.8 y). The affected side was compared to the side and these two were compared to the control group. Results were compared between groups using unpaired t-tests.

RESULTS

Thirty-two children with unilateral (13 feet) and bilateral clubfeet (38 feet) were examined at a mean age of 5.9 years (3.1–8.3 y). All feet were initially treated with the Ponseti method including percutaneous Achilles tenotomy and 6 feet did require additional minor surgery (Tibialis anterior tendon transfer, percutaneous Achilles tenotomy or lengthening of the Achilles tendon). Gait analysis showed statistical significant decrease of ankle power at push off compared to the unaffected feet of unilateral cases. The maximal sagittal ankle moment was decreased on the affected feet compared to the unaffected side. The mean foot progression during stance phase was 5.7° of external rotation. There was no significant difference of the maximal dorsiflexion (14.2°), maximal plantarflexion (14.6°) and ROM (28.7°) during the gait cycle compared to the unaffected side. The affected side to the control group showed a significant reduction ($p=0.01$) for the ankle power. ROM and maximal plantar flexion were significant reduced for the Ponseti group compared to the control group. Foot progression angle was also diminished but not significant to the control group. Significant external hip rotation was found for the Ponseti group. No significant reduction in comparison to the control group was seen for knee rotation in the transvers plane. Comparison of the gait results between unaffected site and control group showed statistical significant differences for some parameters.

DISCUSSION & CONCLUSIONS

The increased external hip rotation can be explained as a compensation mechanism for the foot progression angle. Our results suggest that using the non-affected side as control group for the affected side cannot be recommended. Compliance and gait variability in children at an age between 3-5 years are bias in our study. Gait analysis demonstrated that clubfeet treated with the Ponseti method show only minor differences compared to the control group. Normal ankle motion and an external foot progression during gait were achieved in most cases.

REFERENCES

[1] Huber H, (2004) J Bone Joint Surg Am 86-A: 1203–1210. [2] Karol LA, (2009) Clin Orthop Relat Res 467: 1206–1213 [3] Jeans K, (2010) J Pediatr Orthop 30: 82–89 [4] Karol LA (2005) J Pediatr Orthop 25: 236–240

RELATIONSHIP BETWEEN PLANTAR PRESSURE AND PERCEIVED QUALITY OF LIFE IN CLUBFOOT

Julie Stebbins[1], Joanne Bates[1], Jennifer McCahill[1] and Tim Theologis[1]

[1]Nuffield Orthopaedic Centre, Oxford Gait Laboratory, Oxford, UK

INTRODUCTION

While treatment of infants with clubfoot is becoming more standardised, treatment of the older child remains largely empirical. There are currently no clear guidelines on how and when to treat children with over-corrected or residual/relapsed clubfoot deformity. The aim of this pilot study was to assess the relationship between plantar pressure, combined with motion capture, and perceived quality of life in this population, to determine if this could potentially be used to guide treatment.

PATIENTS/MATERIALS and METHODS

10 children with clubfoot were included in this study (age 6-13 years). Markers were attached to both legs and feet according to the Oxford Foot Model[1]. Subjects were instructed to walk at self-selected speed. Motion data were collected using a 12-camera Vicon MX system (Vicon, UK) and pressure data were collected using a Novel-M platform (Novel, Germany). The footprint was subdivided into 5 areas (medial and lateral hindfoot, midfoot, medial and lateral forefoot) using markers projected onto the footprint at the time corresponding to mid-stance[2]. Peak pressure from the total footprint and each sub-area were extracted from the pressure data. The parent of each subject completed the validated Oxford Ankle Foot Questionnaire (OxAFQ)[3] to assess foot-related quality of life. Scores from the domains of "physical", "school and play" and "emotional" were calculated, and Pearson's correlation was used to assess the relationship between these and the peak pressure variables.

RESULTS

Little to no correlation was found between any of the dimensions of the OxAFQ and midfoot or hindfoot areas. However, significant correlations were found between the "physical" and "school and play" dimensions and the forefoot (both lateral and medial). Figure 1 shows an example of this.

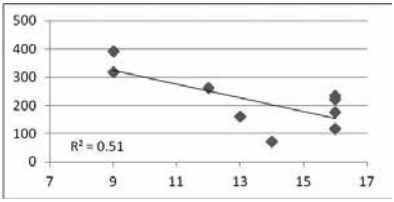


Figure 1: Correlation between lateral forefoot pressure and the OxAFQ "school and play" domain.

DISCUSSION & CONCLUSIONS

A previous study conducted by the authors found very little correlation between dynamic foot deformity (measured by the OFM) and perceived quality of life, as determined by the foot deformity. The current study demonstrated much higher correlations between peak pressure values and the OxAFQ, indicating plantar pressure distribution may have more impact on quality of life than the actual foot deformity itself. This pilot study shows promise for using plantar pressure, in combination with dynamic measurement of foot biomechanics, to predict the impact of the severity of foot deformity on perceived quality of life. More subjects are required to verify these findings.

REFERENCES

[1] Stebbins et al, Gait & Posture 2006 43(4): 401-410.

[2] Giacomozzi *et al*, MBEC 2000, 38(2):156-63.

[3] Morris et al, JBJS 2009 90B: 1451-1456

THE ROLE OF PEDOBAROGRAPHIC ASSESSMENT OF FLATFOOT AND IT'S PLACE AS AN OUTCOME MEASURE

Lambros Athanatos[1], Mathew Nixon[2], Gill Holmes[3], Leroy James[2] and Alf Bass[2]

[1]Alder Hey Children's Hospital, Trauma & Orthopaedics, Liverpool, United Kingdom
[2]Alder Hey Children's Hospital, Trauma & Orthopaedics, Liverpool, UK
[3]Alder Hey Children's Hospital, North West Movement Analysis Centre, Liverpool, UK

INTRODUCTION

Flexible flat foot is considered one of the commonest normal variants in children's orthopaedic practice (1). The weight-bearing foot is usually regarded as flexible on the basis of results from clinical and radiographic examination as well as measured foot-ground pressure pattern (2).

Our aim was to compare the pedobarographic and radiographic findings of normal arched and symptomatic flexible flat feet and investigate if there were sensitive markers that could be used in selecting patients for surgical correction.

PATIENTS/MATERIALS and METHODS

We retrospectively collected data from eighteen patients (ten to sixteen year old). Our control group consisted of ten patients (twenty feet) with normal arched feet and the study group of eight patients (fifteen feet) with symptomatic flat feet who were awaiting surgical correction. The mean and standard deviations of three radiographic markers (Calcaneal pitch, Naviculocuboid overlap and lateral Talo-1st metatarsal angle) in addition to foot pressures measured at the hindfoot, medial/lateral/total midfoot (MMF,LMF,TMF), forefoot and the percentage of weight going through the MMF over the TMF (medial midfoot ratio (MMFR) during the mid-stance gait phase are reported. In addition, the sensitivity, specificity, positive predictive value and negative predictive value of the pedobarographic parameters were estimated.

RESULTS

There was a significant difference in the Naviculocuboid overlap ($P<0.001$ T test) and Calcaneal pitch ($P<0.05$ T test) between both groups. The flat feet group had significantly higher MMF, LMF, TMF and MMFR ($P < 0.001$ Mann-Whitney). LMF had the highest sensitivity and negative predictive value (94%) whereas MMF, TMF and MMFR had the highest specificity and positive predictive value (100%).

DISCUSSION & CONCLUSIONS

Compared to our control group, patients with symptomatic flexible flat feet had significantly higher pressures distributed in the midfoot, in particular in the medial midfoot. Pedobarography appears to be a sensitive and specific tool that can be used, in conjunction with clinical and radiographic findings, in diagnosing flat feet.

Our study suggests that pedobarography could be used to measure the degree of deformity before and after surgical intervention.

REFERENCES

1. Benedetti MG, Ceccarelli F, Berti L, Luciani D, Catani F, Boschi M, Giannini S. Diagnosis of flexible flatfoot in children: a systematic clinical approach. Orthopaedics. 2011; 34(2): 94

2. Aharonson Z, Arcan M, Steinback TV. Foot-ground pressure pattern of flexible flatfoot in children with and without correction of calcaneovalgus. Clin Orthop Relat Res. 1992; (278): 177-82

MARKER-BASED FOOT POSTURE ASSESSMENT IN CHILDREN

Catriona M Kerr[1], Julie Stebbins[2], Tim Theologis[2] and Amy B Zavatsky[3]

[1]University of Oxford, 1Department of Engineering Science, Oxford, UK
[2]Nuffield Orthopaedic Centre NHS Trust, Oxford Gait Laboratory, Oxford, UK
[3]University of Oxford, Department of Engineering Science, Oxford, UK

INTRODUCTION

Foot posture assessment methods are often subjective, and based on standing posture. The Oxford Foot Model (OFM) is a clinically tested and validated model [1] used to assess foot deformity during walking. An assessment of OFM components which distinguish neutral, flat, and symptomatic flat feet is presented here.

PATIENTS/MATERIALS and METHODS

A clinical assessment of the lower limbs was performed on 89 children (14 patients with symptomatic flat foot (SF, n=28 feet), and 75 volunteers with asymptomatic feet and no known pathology; 39 males, 50 females; 4.9 to 17.1 years old). Weightbearing clinical assessment of the asymptomatic group was used to classify the foot as normal (NN, n=81) or flat (NF, n=69). Reflective markers were placed at known locations on the lower limb and foot [1], and were tracked using a 12 camera Vicon MX system. Mean values of each OFM Euler angle were calculated during three seconds of quiet standing. During walking, the median angular values at heel strike, 50% stance and foot off were calculated for each subject. Each foot was treated as an independent sample and ANOVA tests were used to assess whether OFM angles differed between groups.

RESULTS

During standing, five OFM angles were found to be different between groups. The eversion of the hindfoot relative to the tibia was significantly different between all groups. Foot descriptions used for grouping are largely based on the degree of hindfoot eversion so a difference between normal and flat feet could be expected. The difference between symptomatic and asymptomatic flat feet may reflect severity. The forefoot was also more pronated relative to the tibia in the flatfooted populations. This again could be a reflection of the original classification technique. The increased forefoot abduction relative to the hindfoot and tibia in the symptomatic population, may be a reflection of a midfoot break associated with more severe flat foot.

At foot strike and 50% stance the symptomatic population retains increased forefoot abduction relative to the hindfoot and tibia, as well as increased hindfoot eversion relative to the tibia. At foot off, these differences are further emphasised, with seven of the nine OFM angles tested differing between groups. Also at foot off we observe reduced plantarflexion of the forefoot and hindfoot relative to the tibia in the symptomatic group compared to the asymptomatic groups. This may be caused by an inability to stabilise the foot structure and may be associated with a reduced propulsive gait.

DISCUSSION & CONCLUSIONS

Elements of the OFM may be used to assess flat feet. Some measures have been shown to be associated only with symptomatic flat foot; these may be important in predicting the future for asymptomatic flat feet. Differences between symptomatic and asymptomatic feet are most pronounced at foot off.

REFERENCES

1. Stebbins J, Harrington M, Thompson N, Zavatsky A, Theologis T: **Repeatability of a model for measuring multi-segment foot kinematics in children.** *Gait & Posture* 2006, **23**:401-410.

VALIDATION OF A FE-FOOT MODEL WITH A DUMMY MODEL

Christian Wyss[1] and Reinald Brunner[1]

[1]Laboratory for Movement Analysis, University Children's Hospital Basel, University of Basel, Basel, Switzerland

INTRODUCTION

Daily routine does not allow determining joint reaction forces and moments or stress and strain in vivo. For surgical decision making understanding of foot function is essential. Finite element analysis offers one way to calculate the intra-articular forces and moments in the foot. Often the authors considered the standing foot (2) or did a quasistatic examination of momentary loads during stance (1). The aim of this study was to develop a dynamic approach to get the intra-articular forces and moments in every foot joint during gait. For this reason a FE model was created and a validated using a dummy model.

PATIENTS/MATERIALS and METHODS

Gait analysis in one patient was done with a Vicon MX System and 6 cameras, one AMTI Force plate and one EMED SF pressure measurement platform. The "GaitLowerExtremity" model from the ANYBODY Repository AMMRV1.4.1 and ANYBODY Version 5.1 was used to determine the muscle forces of the lower leg during gait. The muscle forces from the ANYBODY model, the regional reaction forces from the EMED SF platform and the 3D kinematics were used to build up the FE-model. A "standard foot model" was created from a CT scan of one healthy foot. This model was imported in ANSYS Workbench V.14.0 and scaled according to the patient's standard x-rays. The bony segments were linked by revolute joints. This model was validated by measuring the intra-articular forces at the ankle joint in a dummy model constructed by aluminium and computing the FE Model using data for both analysis from the same patient at 50 % stance phase.

RESULTS

Validation of the FE model shows a good correlation of the measured data in the dummy model and the computed data at the ankle joint in the FE model. Only the moments in z direction (vertical to the floor) showed a difference of 19%. All other differences were in a range between 2 and 8 %.

	Force x	Force y	Force z	Force total
FE-Model	-526	-44	-2630	2682
Dummy	-649	3	-2826	2895
% delta	5	2	7	8
	Moment x	Moment y	Moment z	Moment tot.
FE-Model	6237	24381	-1330	25202
Dummy	7310	22980	-6159	23878
% delta	4	6	19	5

Figure 1: Comparison Dummy-Model versus FE Model

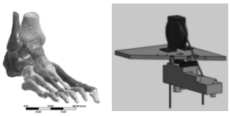


Figure 2: FE-Model and Dummy Model

DISCUSSION & CONCLUSIONS

For the dynamic validation of the FE model the load during one representative step in mid stance was applied on the dummy model. The results of the dummy model and the FE calculation correlated well. Only the moments in z direction at the ankle joint differed between FE Model and dummy model. The reason is not understood yet and is further analyzed.

REFERENCES

1. Gefen AEA. Biomechanical Analysis of the Three-Dimensional Foot Structure During Gait: A Basic Tool for Clinical Applications. Transaction of ASME. 2000 Dec. 4;122:630–639.

2. Cheung JT-M, Zhang M, Leung AK-L, Fan Y-B. Three-dimensional finite element analysis of the foot during standing—a material sensitivity study. Journal of Biomechanics. 2005 May;38(5):1045–1054.

12.00 - 13.00	**LUNCH IN THE EXHIBITION HALL**
13.00 - 14.30	**POSTER PRESENTATIONS IN EXHIBITION HALL & BALCONY**
14.30 - 15.00	**COFFEE IN THE EXHBITION HALL**
15.00 - 15.30	**KEYNOTE SPEAKER II, Hans Forssberg, Professor, PhD, MD, Karolinska Institutet, Stockholm, Sweden** Development of fine motor control (A2)

Curriculum Vitae of Hans Forssberg

Hans Forssberg is professor in neuroscience at Karolinska Institutet and consultant in neuropaediatrics at Astrid Lindgren Children's Hospital in Stockholm, Sweden. He is a member of the Nobel Committee for Physiology and Medicine at KI, and chairman of the European Academy of Childhood Disability.

Forssberg has a broad scientific background with more than 200 publications in translational research on development of motor and cognitive control, as well as in clinical research on neurodevelopmental disorders.

Abstract

Development of fine motor control

Most everyday activities require the manipulation of objects with the fingertips, an ability that is impaired in several neurodevelopmental disorders, e.g., CP and ADHD.

Various factors have been identified that influence performance in manipulative tasks, such as strength, independent finger movements, finger speed, and the precise control of the fingertip forces employed to the object. We have investigated the development of motor control functions involved in object manipulation by means of behavioural and neuroimaging studies in typically developing children and children with neurodevelopmental disorders.

Recently we have focused on sensorimotor mechanisms involved in manipulation of unstable objects aiming at developing a clinical method to evaluate dexterity. This complex motor task is controlled by a striato-frontal-parietal-cerebellar network in which different parts seem to be designated to control specific motor functions, e.g., strength and dexterity.

15.30 - 17.00	**SESSION 6a (C4)** **Cerebral Palsy Effect** **Chairmen: Per Åstrand, Kaat Desloovere**
O62 Romei, Marianna	Robotic assisted gait training and gait pattern in children affected with Cerebral Palsy
O63 Gantelius, Stefan	Botulinum toxin injections in lower extremity changes activity in upper extremity in Cerebral Palsy-a case report
O64 Morais Filho, Cesar	The impact of semitendinosus transfer at knee flexion deformity and crouch gait in patients with Cerebral Palsy
O65 Desailly, Eric	Supervised classification of the effect of hamstrings lengthening in cerebral palsy children after single event multilevel surgery

O66 Vegvari, Dóra	Proximal rectus femoris release does not influence the effects of distal rectus femoris transfer on the knee in Cerebral Palsy
O67 Lehtonen, Krista	The impact of multilevel surgery on functional abilities and participation in adolescents with Cerebral Palsy (CP)
O68 Langerak, Nelleke	Gait status of adults with bilateral spastic Cerebral Palsy more than 15 years after orthopaedic interventions
O69 Schwartz, Michael	Identifying historical selection criteria for femoral derotational osteotomy using the random forest algorithm
O70 Schwartz, Michael	Patterns of historical outcomes for femoral derotational osteotomy revealed by the random forest algorithm
15.30 - 17.00	**SESSION 6b (C4)** **Gait assessment** **Chairmen: Julie Stebbins, Bertram Müller**
O71 Brunner, Reinald	The influence of muscle strength on kinematic gait deviations is similar across patients with various pathologies
O72 Esbjörnsson, Anna-Clara	The influence of walking speed on the gait deviation index in individuals with Rheumatoid Arthritis

O73 Sloot, Lizeth	Self-paced versus fixed speed in treadmill walking
O74 Vardaxis, Vassilios	Bilateral lower extremity stiffness during transition from stair descent to level walking in unilateral total hip arthroplasty patients and controls
O75 Syczewska, Malgorzata	Gait changes in patients after jaw and mandible reconstruction with fibula and iliac crest bone and soft tissue grafts
O76 Lenaerts, Gerlinde	Gait assymetry and trunk torsion in scoliotic girls
O77 Petrarca, Maurizio	Gait deviations in patients operated on bladder extrophy
O78 Franzén, Erica	Cognitive and motor dual-tasking affects spatio-temporal gait characteristics in subjects with Parkinson's disease
O79 Rozumalski, Adam	Vertebral Motions of the Lumbar Spine During Gait

ROBOTIC ASSISTED GAIT TRAINING AND GAIT PATTERN IN CHILDREN AFFECTED WITH CEREBRAL PALSY

Marianna Romei[1], Abbondanza Montinaro[1], Luigi Piccinini[2], Cristina Maghini[2] and Anna C Turconi[2]

[1]IRCCS E.Medea, Bioengineering Department, Bosisio Parini (LC), Italy
[2]IRCCS E.Medea, Functional Rehabilitation Dept., Bosisio Parini (LC), Italy

INTRODUCTION

Improving and maintaining walking function is often a primary focus in the management of children with Cerebral Palsy (CP). Robotic assisted gait training (RAGT) is a rehabilitation strategy based on the principle that task-specific and repetitive practice is required to develop and improve a motor skill such as walking[1]. Previous studies[2,3] reported improvement after RAGT in functional and motor abilities in children with acquired or congenital brain injury, but the effect of RAGT on gait pattern has not been yet assessed. The aim of this study was to evaluate through 3D Gait Analysis (3DGA) if adding paediatric RAGT to task-oriented physiotherapy (TOP) in children with CP could improve gait pattern compared to intensive TOP.

PATIENTS/MATERIALS and METHODS

19 children with bilateral spastic CP, aged 4 to 16 years, were divided into two groups: the 9 children of RAGT+TOP group had 20 RAGT sessions and 20 TOP; the 10 children of ITOP group had 40 sessions of TOP.

RAGT was performed using the Lokomat (Hocoma Inc, Zurich, Switzerland), and during each RAGT session, the children walked for 30 minutes with body-weight support fixed at 50% for the entire duration of the training and the leading force at 100%. The only parameter that was modified during the treatment sessions was the gait velocity, which was initially set at 1.2 km/h for all the children and was gradually increased to 1.6 km/h for the youngest children and to 2.0 km/h for the oldest children.

For standardization of TOP, a group of specific exercises for improving gait, balance and functional abilities, strengthening extensor muscle and stretching of flexor muscle was chosen.

Three clinical assessments were performed: pre (T0), post-treatment (T1) and 3 months after the end of treatment (T2).

As outcome measures gait velocity and Range Of Motion of lower limb joints (pelvic, hip and knee) on sagittal plane were calculated. For both the groups, the mean values for each parameter was calculated at T0, T1 and T2. In addition, for each child changes in outcomes were calculated by subtracting the value at T0 from the value obtained at T1 and at T2. Paired and unpaired T-Test was used to assess respectively within- and between groups differences ($p<0.05$).

RESULTS

Both the groups didn't significantly increase their gait speed or improve their ROM at lower limb joints after the training.

No between groups differences were found after the training and three months after the training.

DISCUSSION & CONCLUSIONS

Compared to intensive TOP alone, the addition of RAGT to TOP didn't significantly change lower limb joint kinematic of children with CP and the gait pattern was maintained over time.

REFERENCES

[1] Willoughby KL, et Al. Arch Phys Med Rehabil 2010; 91 (3): 333-339
[2] Meyer-Heim A, et Al. Arch Dis Child 2009; 94(8): 615-620
[3] Borggraefe I, et Al. Eur J Paed Neur 2010; 14(6): 496-502

BOTULINUM TOXIN INJECTIONS IN LOWER EXTREMITY CHANGES ACTIVITY IN UPPER EXTREMITY IN CEREBRAL PALSY-A CASE REPORT

Stefan Gantelius[1], Annika Viklund[1], Maria Hagströmer[2] and Eva Pontén[1]

[1]Karolinska Institutet, Women´s and Children´s health, Stockholm, Sweden
[2]Karolinska Institutet, Department of Neurobiology, Care Sciences and Society , Stockholm, Sweden

INTRODUCTION

Botulinum toxin A (BoNT-A) is frequently used to reduce spasticity in children with cerebral palsy (CP). The spasticity reducing effect is today well documented, while aspects of the clinical effect is a field for further research. Assessing clinical effect is often done during specific test situations. The aim of this pilot study was to assess BoNT-A treatment effect in a child with cerebral palsy with an objective tool. The child was assessed before and after BoNT-A treatment in every-day life and normal activities. Discrimination was made between whole body movements, like walking, and arm movements and between movements of the dominant and the non-dominant hand.

PATIENTS/MATERIALS and METHODS

An eleven years old boy with bilateral spastic CP, GMFCS 1, 34 kg was scheduled for BoNT-A treatment because of toe walking due to spasticity. The patient was injected with BoNT-A (Botox ®, Allergan Inc. Irvine, California, USA) in the gastrocnemius (100 U) and soleus (50 U) muscle bilaterally. Physical activity was assessed with accelerometers (GT1M, Actigraf MTI, Pensacola, Florida, USA) for 4 days (weekend plus 2 weekdays) before, and 3 weeks after injection. Accelerometers were put around both wrists, one ankle and the waist. Activity was divided into four levels; inactivity, light, moderate and vigorous activity [1]. The percentage of time spent in each activity level was determined.

RESULTS

The right arm showed a reduced time in inactivity (66% to 52%) and an increased time in light (16% to 24%) and moderate (11% to 16%) activity (fig. 1). The leg showed an almost unchanged time in inactivity (81% to 80%) and a small increase in light (7% to 10%) activity (fig. 2). Left and right arm showed similar activity, and waist and leg showed similar activity, both before and after BoNT-A injections.

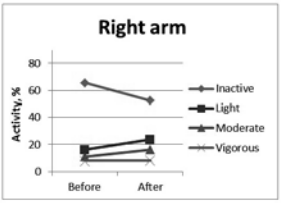


Fig 1

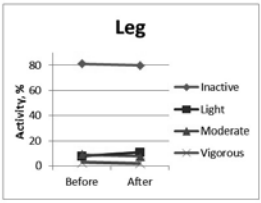


Fig 2

DISCUSSION & CONCLUSIONS

This case report shows that, in CP, BoNT-A injections in the lower extremities can increase the activity in the upper extremities, even though nothing was injected in the arms. This indicates that BoNT-A treatment has an influence on the gait reflex. The 4-accelerometer set up in evaluation of BoNT-A treatment can add valuable information of treatment effect on patient activity. A study with more patients, patients with different GMFCS levels and patients with different muscles treated would be of interest.

REFERENCES

1) Freedson PS et al. *Med Sci Sports Exerc.* 1998;30:777-781.

THE IMPACT OF SEMITENDINOSUS TRANSFER AT KNEE FLEXION DEFORMITY AND CROUCH GAIT IN PATIENTS WITH CEREBRAL PALSY

Mauro C Morais Filho[1], Cátia M Kawamura[1], Daniella L Neves[1], Marcelo H Fujino[1], Carlos A Santos[1] and José Augusto F Lopes[1]

[1]AACD, Gait Laboratory, São Paulo, Brazil

INTRODUCTION

Hamstrings surgical lengthening (HL) is a well established treatment option for knee deformity and crouch gait in cerebral palsy (CP). Despite the benefits at knee extension during stance phase, HL can also produce some degree of weakness at hip extensors and increase of anterior pelvic tilt. In order to avoid these potential effects, the transfer of semitendinosus to distal femur (ST Tx) has been suggested [1]. The objective of the study was to analyze the effects of ST Tx at knee flexion deformity and crouch gait in a group of cerebral palsy patients.

PATIENTS/MATERIALS and METHODS

Patients with diplegic CP, GMFCS levels I to III, without previous surgical procedures at knee, underwent to bilateral medial HL or ST Tx at our hospital from May 1996 to September 2009 and with complete pre and post-operative documentation at gait laboratory. Thirty one patients (62 sides) matched the inclusion criteria. The subjects were divided in 2 groups according surgical procedures at knees. In group A were patients who received medial HL (16 patients), while group B consisted of those underwent to medial HL (gracilis and semimembranosus) and ST Tx (15 patients). Clinical and kinematics parameters were analyzed and results were compared between groups (Wilcoxon and Mann-Whitney tests).

RESULTS

The mean age at surgery and follow-up time were similar in the groups A (12.1 years at surgery and follow-up of 1.4 years) and B (12.4 years at surgery and follow-up of 1.6 years). Knee flexion deformity reduction (from 8.4^{o} to 0.9^{o}) was observed only in the group B ($p=0.01$). There was observed an increase of anterior pelvic tilt after surgery in groups A (from 17.2 to 21.1^{o}) and B (from 12.1 to 20^{o}), and it exhibited a tendency to be more significant at group B ($p=0.051$). Hip extension at stance phase was not altered by surgical procedures in both groups. Knee extension at stance phase improved from 22.4 to 13.5^{o} in the group A ($p=0.034$) and from 35 to 13.2^{o} in the group B ($p=0.001$). The reduction of knee flexion during stance phase was more significant in the group B ($p=0.009$). The GDI improved from 54.44 to 66.66 in group A and from 54.94 to 63.89 in group B.

DISCUSSION & CONCLUSIONS

The combined use of medial HL and ST Tx was more effective than isolated medial HL to improve static and dynamic knee extension in the group studied. An increase of anterior pelvic tilt occurred in both groups and semitendinosus transfer did not prevent it in the present study.

REFERENCES

1. Ma FY, Selber P, Nattrass GR, Harvey AR, Wolfe R, Graham HK.Lengthening and transfer of hamstrings for a flexion deformity of the knee in children with bilateral cerebral palsy. J Bone Joint Surg [Br] 2006; 88B: 248-254.

SUPERVISED CLASSIFICATION OF THE EFFECT OF HAMSTRINGS LENGTHENING IN CEREBRAL PALSY CHILDREN AFTER SINGLE EVENT MULTILEVEL SURGERY

Eric Desailly[1], Abdennour Sebsadji[1], Daniel Yepremian[1], Khalifa Djemal[2], Philippe Hoppenot[2], Néjib Khouri[3, 1]

[1]Fondation Ellen Poidatz, Motion Analysis Unit, St Fargeau Ponthierry, France
[2]Université d'Evry , IBISC, Evry, France
[3]Armand Trousseau Hospital, Department of Pediatric Orthopaedic Surgery, Paris, France

INTRODUCTION

Single event multilevel surgery (SEMLS) purpose is to improve the cerebral palsy (CP) children's gait by associating multiple surgeries on the same therapeutic time. It is therefore complex to isolate the effect of these actions in this multifocal context. To address this problem we chose to specifically identify the effect of hamstrings lengthening (HL) in CP children with crouch gait. The aims of this study were to describe the specific parameters influenced by HL and to classify the positive or not-positive effect of HL in SEMLS.

PATIENTS/MATERIALS and METHODS

42 CP children (12±3 years) were divided into two groups: 31 (G1= 60 lower limbs (LL)) and 11 (G2= 20 LL), respectively having followed and not-followed HL among all the associated surgeries. All patients had clinical gait analysis before and 1.9±0.8 years after surgery. The GDI is calculated [1]. All kinematic data (angles, velocities) were double-normalized and conditioned in two vectors. A homogeneity test (G1 vs G2) selected the kinematic parameters influenced by HL (t-test, $p<0.005$). Principal component analysis identified the minimum descriptors characterizing the effect of HL. Several classifiers (Regularized Discriminant Analysis (RDA) and linear or nonlinear Support Vector Machines (SVM)) were supervised by 6 experts' opinions. Experts' opinions were based on video and kinematic curves comparison between pre and post-surgery conditions. The classifiers performances in learning, validation (leave one out) and generalization were compared .

RESULTS

GDI results showed that 83% of the subjects of G1 were globally improved by SEMLS. Among all the kinematic data, 16 sub-vectors, significantly influenced by HL were selected. Their dimensionality was reduced by principal component analysis. The 6 experts have classified the effect of HL for 37 LL: 24 were positive and 13 not-positive. The classification method with the best performance was the linear SVM with error rate 0% in learning, 5.4% in validation and 6.5% in generalization. In view of the classification system 1/3 of G1 LL were not improved by HL.

DISCUSSION & CONCLUSIONS

This supervised classification and data conditioning techniques are able to categorize the specific effect of HL among all the associated performed procedures in two classes "positive effect" and "not-positive effect". While 83% of patients were improved by SEMLS, HL had positively contributed to this improvement in only 70% of these cases. This methodology can be generalized to study the effect of other surgical procedures.

REFERENCES

[1] Schwartz M., Rozumalski A., Gait & Posture, 28(3), 351-357.

PROXIMAL RECTUS FEMORIS RELEASE DOES NOT INFLUENCE THE EFFECTS OF DISTAL RECTUS FEMORIS TRANSFER ON THE KNEE IN CEREBRAL PALSY

Dóra Vegvari[1], Sebastian I. Wolf[2], Daniel Heitzmann[2], Frank Braatz[2], Matthias Klotz[2] and Thomas Dreher[2]

[1]Semmelweis University, Department of Orthopaedics, Budapest, Hungary
[2]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

Dysfunction of the biarticular rectus femoris (RF) muscle is common among CP children [1, 2]. While the proximal part works as a hip flexor, the distal part extends the knee [3]. In CP children with increased anterior pelvic tilt and hip flexion contracture proximal RF release was considered [4]. At the knee, pathological RF activation leads to stiff knee gait, which is commonly treated by distal rectus femoris transfer (DRFT) [1,2]. The benefits after DRFT for knee joint motion are well described. However, no reports evaluated if a concomitant proximal RF release affects the knee kinematics.

PATIENTS/MATERIALS and METHODS

In a matched pair analysis, the short- and long-term outcome of 20 patients with spastic diplegic cerebral palsy, who were treated with DRFT and concomitant proximal RF release (RTRR group) was compared with the outcome of 20 patients, in which DRFT but no proximal RF release (RT group) was done. The matching criteria included: maximum knee flexion in swing and ROM in swing as well as age at surgery, BMI and GGI. Standardized three-dimensional gait analysis was done before (E0), 1 year (E1) and 8-9 years (E2; RT: 8.1±2.1; RTRR: 9.2±2.2) after surgery.

RESULTS

Knee kinematics no group differences were found at any examination (Table I). Peak knee flexion in swing (pKFSw) showed a slight but not significant increase in both groups at E1. While this was maintained in RTRR group at E2, there was a minimal but not significant decrease in RT group. Timing of pKFSw, range of knee flexion and knee flexion velocity improved after surgery but tended to deteriorate over the years in either group.

Table I: Gait analysis outcome		RT			RTRR			Group diff
		E0	E1	E2	E0	E1	E2	
mean anterior pelvic tilt	[deg.]	16 (7)	19 (7)	17 (9)	20 (7)	22 (7)	20 (7)	E0,E1
pKFSw	[deg.]	52 (12)	55 (8)	53 (10)	51 (10)	54 (9)	55 (8)	-
timing of pKFSw	[%GC]	81 (4)	79 (5)*	78 (3)*	80 (5)	78 (5)	78 (5)*	-
knee ROM in swing	[deg.]	22 (8)	37 (10)*	34 (11)*	22 (8)	37 (10)*	33 (10)*	-
knee flexion velocity	[deg./%GC]	0.8 (0.4)	1.2 (0.4)*	1.0 (0.5)*	0.8 (0.3)	1.2 (0.4)*	1.0 (0.6)*	-
Legend: two-way ANOVA: * significant difference from E0, pKFSw (peak knee flexion in swing), ROM (range of motion)								

DISCUSSION & CONCLUSIONS

The results of the present study for the first time suggest that the influences of proximal RF release on DRFT effects on the knee joint are negligible. Two possible explanations should be considered. First, the findings may be explained by a permanent elimination of RF function on the knee after DRFT, which would be unaffected by proximal release and would underline the efficiency of DRFT. Secondly, surgery in the proximal part does not influence the distal part. This would represent a new impact on function of biarticular muscles with a clinical importance for treatment planning in CP.

REFERENCES

[1] Gage JR. and Perry J. et al., Dev Med Child Neurol. 1987;29:159-66.

[2] Saw A. et al, J Pediatr Orthop. 2003;23:672-8.

[3] Markee JE. et al., J Bone Joint Surg Am. 1955;37:125-42.7

[4] Sutherland DH. et al., J Pediatr Orthop. 1990;10:433-41.

THE IMPACT OF MULTILEVEL SURGERY ON FUNCTIONAL ABILITIES AND PARTICIPATION IN ADOLESCENTS WITH CEREBRAL PALSY (CP)

Krista Lehtonen, MSc.[1, 2], Nea Vänskä, MSc.[2], Tuula Niemelä, PT[3], Arja Piirainen PhD[2], Helena Mäenpää, MD, PhD[3]

[1]Metropolia University of Applied Sciences, Helsinki, Finland
[2]University of Jyväskylä, Finland
[3]Helsinki University Hospital for Children and Adolescents, HUCH, Helsinki, Finland

INTRODUCTION

The outcome of Single Event Multilevel Surgery (SEMLS) has mainly been studied by using quantitative data eg. gait analysis. The focus has been on body functions and structure and on activities (gait) classified according to WHO International Classification of Functioning, Disability and Health (ICF) domains. There is growing evidence that SEMLS can improve gait. Functional abilities and changes in ICF participation domain have been studied less (1). The purpose of this mixed method study was to evaluate the long-term effectiveness of SEMLS in children with CP on physical functioning and coping in real life environment. This paper shares the pilot results from an ongoing project in Helsinki University Central Hospital (HUCH).

PATIENTS/MATERIALS and METHODS

The participants were 8 adolescents with CP (GMFCS II-IV, age at operation 10,1-14,8 years) who had SEMLS in HUCH. In this study quantitative data was collected from both gait analysis (3D Vicon System, UK) and clinical examination done preoperatively and two and five years after. Quantitative data was analysed using SPSS 19. Qualitative data was gathered by interviewing the patients five years or more postoperatively. Sessions were taped, written down and analysed by phenomenographic methology (2).

RESULTS

Quantitative data showed that changes seen 2 years postoperatively in gait kinematics, time-distance parameters and clinical examination results were reduced 5 years postoperatively, when only significant changes were improvements in knee extension and foot progression in stance and popliteal angle ROM. Qualitative data showed that conceptions of the impact of SEMLS formed two main categories. In the first category patients expressed that their mobility, function, gait pattern improved and they enjoyed moving more. The operation enabled a change in functioning and possibility to maintain mobility in the future. Second category included unrealistic expectations before the operation and perception of deterioration in mobility over time after the operation. Participants related this to the fast growth period, other surgical procedures and giving up intensive physiotherapy. Perception of deterioration was combined with contentment and acceptance of current abilities and disability as a permanent part of life.

DISCUSSION & CONCLUSIONS

The study revealed valuable insights from young people`s perspectives. They viewed that multilevel surgery improved their physical functioning and were satisfied with their ability to participate in age related activities five years after surgery even though deterioration of abilities was both experienced and seen in quantitative data.

REFERENCES

(1) McGinley et al. 2012. *Dev Med Child Neurol.* 54 (2):117-28
(2) Åkerlind G. 2008. *Teaching in higher education* 13 (6):633-44.

GAIT STATUS OF ADULTS WITH BILATERAL SPASTIC CEREBRAL PALSY MORE THAN 15 YEARS AFTER ORTHOPAEDIC INTERVENTIONS

Nelleke G. Langerak[1], Robert P. Lamberts[2], John Cockcroft[3], Jacques Du Toit[4] and Graham Fieggen[5]

[1]Stellenbosch University, Physiotherapy, Parow, Cape Town, South AFrica
[2]University of Cape Town, Human Biology, Cape Town, South Africa
[3]Stellenbosch University, Mechanical and Mechatronic Engineering, Stellenbosch, South Africa
[4]Tygerberg Hospital, Paediatric Orthopaedic Surgery, Parow, Cape Town, South Africa
[5]University of Cape Town, Neurosurgery, Cape Town, South Africa

INTRODUCTION

In the last decades an increased number of publications focused on the effects of orthopaedic interventions in children with cerebral palsy (CP) [1]. However, there is a lack of information on the long-term effects of these interventions into adulthood. Therefore the aim of this study is to describe the gait status of adults with bilateral spastic CP who received soft-tissue and/or bony orthopaedic surgeries more than 15 years ago.

PATIENTS/MATERIALS and METHODS

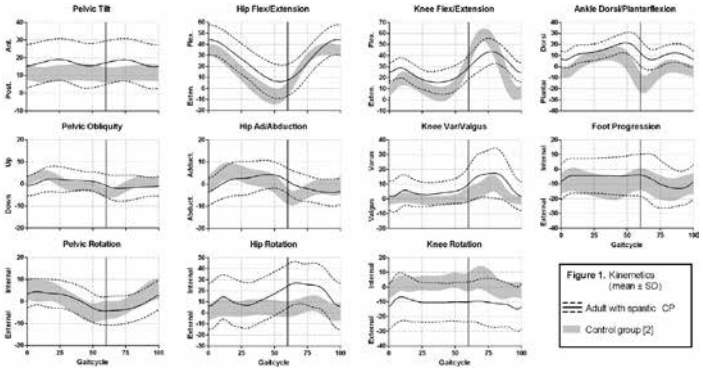
Inclusion criteria were the diagnosis of bilateral spastic CP, received orthopaedic interventions before 1996, and classified pre-operatively as Gross Motor Function Classification System (GMFCS) levels I-III. Kinematic 3dimensional gait data was collected with an 8-camera Vicon system of which 3 trials (both sides) were selected for analysis.

RESULTS

Twenty subjects were classified as GMFCS levels I (n=9), II (n=10) and III (n=1) before first surgery. The mean age was 5.7 ± 2.9 yrs, while they were 32.8 ± 7.7 yrs at time of assessment. The mean time between first surgery and assessments was 27.1 ± 7.0 yrs. Table 1 shows the orthopaedic surgeries performed, while Figure 1 presents the Kinematic data.

Table 1. Number of subjects who underwent at least one orthopaedic intervention

	n (%)
Soft-tissue surgery	
Achilles tendon	19 (95)
Gastrocnemius	4 (20)
Hamstrings	11 (55)
Rectus Femoris	7 (35)
Adductors	6 (30)
Iliopsoas	5 (25)
Abd Hallucis Longus	2 (10)
Tibialis Posterior	3 (15)
At least one soft -tissue surgery	**20 (100)**
Bony surgery	
Femoral derotation	2 (10)
Tibial derotation	2 (10)
Ankle/foot	5 (25)
Toe	0 (0)
At least one bony surgery	**6 (30)**



DISCUSSION & CONCLUSIONS

Adults with bilateral spastic CP who received orthopaedic surgery >15 years ago walked with an increased flexion gait pattern and lever arm rotational malalignment (increased femoral anteversion and external tibial torsion). The increased foot dorsiflexion gait pattern might be secondary to the high incidence of Achilles tendon lengthening, whereas lever arm dysfunction surgery (derotation osteotomies) was underperformed in the past. The study cohort had a higher stiff knee gait pattern than subjects receiving additional selective dorsal rhizotomy [2]. More long-term follow-up studies with larger and more distinguished study cohorts will assist in further optimising and choosing the correct treatment protocol.

REFERENCES

[1] JL McGinley *et al*, DMCN, 54: 117–128, 2012, [2] NG Langerak *et al*, Gait&Posture, 35: 244–249, 2012.

IDENTIFYING HISTORICAL SELECTION CRITERIA FOR FEMORAL DEROTATIONAL OSTEOTOMY USING THE RANDOM FOREST ALGORITHM

Michael H. Schwartz[1], Adam Rozumalski[1] and Tom F. Novacheck[1]

[1]Gillette Children's Specialty Healthcare, Center for Gait and Motion Analysis, St. Paul, United States

INTRODUCTION

Internal rotation gait is an often observed compensation for excessive femoral anteversion in children with cerebral palsy [1]. Femoral derotational osteotomies (FDO) are commonly performed as a corrective measure, with generally good and well maintained outcomes. However, concerns persist regarding "overcorrection" and recurrence [2,3]. There are currently no widely accepted criteria for FDO, and there is an ongoing debate over the relative importance of gait versus physical exam data [3]. The purpose of this study was to discover the historical selection criteria at one center by using machine learning methods to evaluate a large group of limbs that underwent single-event multi-level surgery (SEMLS).

PATIENTS/MATERIALS and METHODS

The local gait database was queried to identify limbs that had undergone SEMLS (more than one major orthopaedic procedure on a limb). Individual surgeries comprising the SEMLS were examined, and limbs were classified based on whether FDO was part of the SEMLS. Data related to medical history, physical examination, and gait were extracted and input into a Random Forest (RF) classifier. The classifier then predicted the FDO status. The RF classifier was built using standard techniques, including model reduction based on variable importance [4]. Limbs predicted to be +FDO were labeled as having met historic criteria, those predicted to be -FDO failed historic criteria.

RESULTS

The RF classifier identified the historic criteria exceptionally well, based on commonly used classifier statistics [Table 1]. There were 31 variables included in the final model. These could be reasonably grouped into the following categories: prior FDO, age, anteversion by physical exam, hip rotation, and foot progression.

Table 1A. Classifier Performance - Confusion Matrix

	Met Criteria	Failed Criteria	Total
SEMLS+FDO	525	48	573
SEMLS-FDO	47	180	227
Total	572	228	800

Table 1B. Classifier Performance - Derived Measures

Acc	Sens	Spec	PPV	NPV	RR	MCC	AUC
0.88	0.92	0.79	0.92	0.79	4.4	0.71	0.93

Acc - accuracy, Sens - sensitivity, Spec - specificity, PPV - pos. pred. value, NPV - neg. pred. value
RR - Relative Risk, MCC - Matthews corr coef, AUC - area under receiver operation characteristic curve

DISCUSSION & CONCLUSIONS

The RF algorithm accurately identified historic selection criteria used at one center to decide on including FDO as part of a SEMLS. The criteria variables and levels are now rigorously defined so that limbs and outcomes can be evaluated against an established 18 year treatment standard.The criteria also allow for objective testing of alternative criteria.

REFERENCES

[1] Arnold AS, et al. (1997) *Dev Med Child Neurol*, **39**:40-442. [2] Õunpuu S, et al. (2002) *J Pediatr Orthop*, **22**:139-145. [3] Dreher T, et al. (2007) *Gait Posture*, **26**:25–31. [4] Breiman L. (2001) *Machine Learning*, **45**:15–32

PATTERNS OF HISTORICAL OUTCOMES FOR FEMORAL DEROTATIONAL OSTEOTOMY REVEALED BY THE RANDOM FOREST ALGORITHM

Michael H. Schwartz[1], Adam Rozumalski[1] and Tom F. Novacheck[1]

[1]Gillette Children's Specialty Healthcare, Center for Gait and Motion Analysis, St. Paul, United States

INTRODUCTION

Femoral derotational osteotomies (FDO) are commonly performed on children with cerebral palsy, yet there are no widely accepted selection criteria for this surgery [1-3]. The Random Forest (RF) algorithm is a machine learning method that has been used to identify historical limb selection criteria for FDO. This study examines the presentation and gait outcomes for limbs meeting the FDO criteria.

PATIENTS/MATERIALS and METHODS

In a related study the RF classifier was applied to 800 limbs that had undergone single-event multi-level surgery (SEMLS). An accurate criteria for predicting which limbs would receive an FDO was found. Multi-dimensional scaling (MDS) was applied to the RF's proximity matrix to reduce the dimensionality of the criteria from 31 variables to 2 [4-5]. Limbs meeting criteria were retained, and a K-means cluster analysis identified groups with similar MDS characteristics.

RESULTS

The clusters could be aptly described as (1) exessive anteversion and internal rotation, (2) mixed levels of anteversion and internal rotation, and (3) excessive anteversion but no internal rotation [Figure 1]. Outcomes for the three groups showed significant GDI changes after surgery [Table 1]. Cluster 1 improved the most, while cluster 3 improved the least. The lack of GDI improvement in cluster 3 was associated with a significant worsening of foot progression.

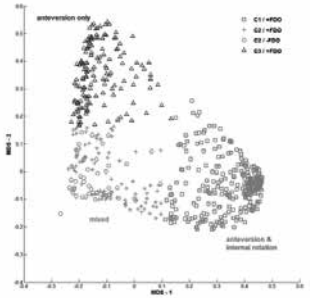


Table 1. Limb Characteristics and GDI Outcome

Cluster	1	2	2	3
FDO status	+FDO	+FDO	-FDO	+FDO
N	285	90	47	150
Prior FDO	1%	26%	26%	0%
Age	8.4	12.2	11.0	7.6
Anteversion	60	46	46	55
Hip Rot. Pre	25.7	14.8	15.1	5.4
GDI pre	64.8	69.5	63.3	73.1
GDI post	78.1	76.1	73.1	76.3
ΔGDI change	13.3	6.6	9.8	3.1
ΔGDI sd	10.2	10.1	9.5	10.0
ΔGDI p-value	<.05	<.05	<.05	<.05

Figure 1 / Table 1. K-means cluster analysis identifies three distinct groups of limbs. Limbs in clusters 1 and 3 all underwent FDO, while those in cluster 2 had a mix of FDO status limbs. Cluster 1 presented with anteversion and internal rotation gait, while cluster 3 had anteversion only.

DISCUSSION & CONCLUSIONS

The data show that if transverse plane alignment is an important outcome, FDO should be reserved for limbs with both excessive anteversion *and* internal rotation gait. Limbs with *only* anteversion are at risk of acquiring iatrogenic pathological external foot progression.

REFERENCES

[1] Staheli LT (1989) *Clin Orthop Relat Res*, **247**:61-6 [2] Ounpuu S, et *al*. (2002) *J Pediatr Orthop*, **22**:139-45. [3] Dreher T, et *al*. (2007) *Gait Posture*, **26**:25-31. [4] Brieman L (2001) *Machine Learning*, **45**:5-32. [5] Cox TF and Cox MAA (2001) *Multidimensional Scaling*, Chapman and Hall

THE INFLUENCE OF MUSCLE STRENGTH ON KINEMATIC GAIT DEVIATIONS IS SIMILAR ACROSS PATIENTS WITH VARIOUS PATHOLOGIES

Katrin Schweizer[1], Jacqueline Romkes[1] and Reinald Brunner[1]

[1]University Children's Hospital Basel (UKBB), Laboratory for Movement Analysis, Basel, Switzerland

INTRODUCTION

At present, patients with walking restrictions are treated according to their primary pathology. However, if the association between muscle strength and kinematic gait deviations behave similar in patients with various pathologies, it might be more efficient to base therapy on the biomechanical constraints.

PATIENTS/MATERIALS and METHODS

All data of patients who were assessed by clinical gait analysis (VICON) and manual muscle strength (MMS) testing in our gait laboratory over the last 12 years were included. The patients walked barefoot at a self-selected speed. The included 716 patients were clustered into seven groups: Orthopaedic uni-/bilateral (OUni/OBi); neurological flaccid uni-/bilateral (NflaUni/NflaBi); neurological spastic uni-/bilateral with/without adequate trunk control (NspUni/NspBi/NspBiNTC). The gait profile score (GPS) [1] was calculated. The mean MMS, derived by clinical testing [2], was the mean over all leg muscle groups. General least square models (software R 2.12.0) were used to assess whether the effects of MMS on GPS differ among patient groups. The GPS offsets at a MMS of 5 were compared between OUni and the other patient groups.

RESULTS

MMS had a strong, negative effect on GPS score (MMS: -3.0±0.2, p<.001). There were no significant differences in this effect among patient groups (p=.848). However, they strongly differed in GPS offset at a MMS of 5 (p<.001) (Tab).

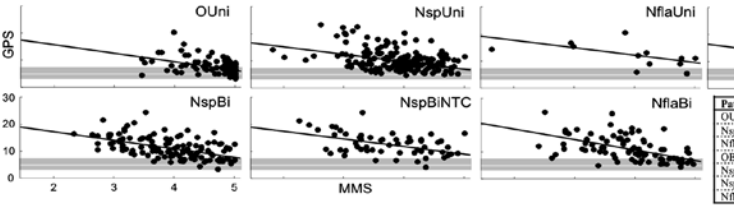


Figure: Presents the mean manual muscle strength (MMS) versus the Gait Profile Score (GPS) in the different patient groups. The gray band represents 95-percentile of the norm.

Patient group	Intercept ± SE	p
OUni (reference)	5.0 ± 0.7	.....
NspUni	0.4 ± 0.4	0.351
NflaUni	2.9 ± 1.1	0.006
OBi	0.2 ± 0.3	0.557
NspBi	1.6 ± 0.4	<0.001
NspBiNTC	2.5 ± 0.6	<0.001
NflaBi	1.6 ± 0.5	0.002

Table: Shows the difference of the GPS offset of Ouni to the other patient groups at a MMS of 5.

DISCUSSION & CONCLUSIONS

The amount of gait deviation increased with the loss of muscle strength, and this behaviour seemed to be independent of the pathology. The severity of the pathology was reflected in the higher GPS (i.e. kinematic deviation) at normal MMS. Note that NflaUni is an exception, possibly biased by the small patient number (n=12). We conclude that gait deviations mainly result from muscle weakness. This knowledge can find clinical implication in treatment planning and in the interpretation of gait compensations in patients with various constraints. The role of the basic disease should not be overemphasised.

REFERENCES

[1] Baker R et al. Gait Posture 2009; 30; [2] Hislop HJ et al., 1999, Manuelle Muskeltests. **SNF project 32003B_127534**

THE INFLUENCE OF WALKING SPEED ON THE GAIT DEVIATION INDEX IN INDIVIDUALS WITH RHEUMATOID ARTHRITIS

Anna-Clara Esbjörnsson[1], Adam Rozumalski[2], Maura D Iversen[3], Michael H Schwartz[2] and Eva W Broström[1]

[1]Karolinska Insitutet, Department of Women´s and Children´s Health, Stockholm, Sweden
[2]Gillette Children's Specialty Healthcare, MD, United States
[3]Brigham & Women's Hospital, Northeastern University and Division of Rheumatology, MA, United States

INTRODUCTION

Decreased walking speed reduces joint rotations in healthy populations. Individuals with Rheumatoid Arthritis (RA) exhibit decreased walking speed and joint rotations, however, debate exists over the influence of walking speed versus pathology on gait deviations in RA. In 2008 the Gait Deviation Index (GDI) was published [1] and in 2011 Rozumalski and Schwartz demonstrated that GDI was influenced by walking speed in a healthy population particularly at slow or fast speeds [2]. Individuals with RA demonstrate reduced GDI scores and walking speed as compared to healthy individuals. Therefore, the aim of this study was to evaluate the impact of walking speed on the GDI in individuals with RA.

PATIENTS/MATERIALS and METHODS

Sixty-three patients with RA (mean age (SD) 57(13) yrs) and 59 age matched adults (mean age (SD) 54 (15) were evaluated retrospectively. Three-dimensional lower extremity joint kinematics and stride parameters of independent barefoot walking at self-selected speed were collected. Two sets of GDI were calculated (free speed (GDI)[1] and speed matched (SMGDI) [2]) for each individual using two different references. The free speed GDI used a reference consisting of free- speed trials from the control group [1]. The speed-matched GDI used a reference matched to the stride speed for which the GDI was being calculated [2].

RESULTS

The average non-dimensional self-selected walking speed for the control group was 0.47 and for the RA group 0.34. For individuals with RA, mean SMGDI-scores were 4 GDI units higher compared to mean GDI-scores ($p= 0.017$), no difference was seen between the scores in healthy subjects. Furthermore, the difference between GDI-scores and SMGDI-scores tends to be greater the slower the individual walks. However, the mean SMGDI-scores for the individuals with RA (91.7 (9.0)) were still significantly lower compared to control subjects (99.9 (8.6)) ($p<0,001$).

DISCUSSION & CONCLUSIONS

The GDI was influenced by walking speed in individuals with RA, particularly at slower speeds. Our results showed a significant 4 units increase between speed-matched GDI and standard GDI for individuals with RA. The difference was greater the slower the individual walked. However, since the SMGDI-score for the RA group remained significantly lower as compared to controls, other factors may also be contributing to gait pathology. Based on the assumption that pathology leads to the slowness exhibited by person with RA, the original GDI would be the better measure of gait deviations, as opposed to the speed matched GDI, as both altered gait patterns and the reduced walking speed are taken into account.

REFERENCES

[1] Schwartz M, Rozumalski A. Gait &Posture 2008;28:351-357.
[2] Rozumalski A, Schwartz M, Conference proceeding, ESMAC, 2011, p 108-109.

SELF-PACED VERSUS FIXED SPEED IN TREADMILL WALKING

Lizeth H Sloot[1], Marjolein Van der Krogt[1] and Jaap Harlaar[1]

[1]VU University Medical Center, Dept. of Rehabilitation Medicine, Amsterdam, The Netherlands

INTRODUCTION

Gait research and clinical gait analysis increasingly involve instrumented treadmills, since they offer new experimental possibilities and increase the number of cycles available for analysis. However, walking on a treadmill is known to effect gait performance, resulting in a lower preferred walking speed, shorter step length, higher cadence, and slightly decreased joint range of motion [1, 2]. It is suggested that these differences might be caused by the imposed walking speed of the treadmill and the absence of optical flow. A feedback-controlled treadmill that follows so called self-paced walking would be a good alternative to allow for small, natural variation in walking speed. On the other hand, it may disturb gait by imposing de- and accelerations of the belt. The purpose of this study was to compare spatiotemporal parameters and joint kinematics between self-paced (SP) and fixed speed (FS) treadmill walking in healthy subjects.

PATIENTS/MATERIALS and METHODS

Eighteen healthy subjects (12 male, age 29±4) walked on a FS and SP controlled dual-belt instrumented treadmill in a speed-matched virtual environment (Gait Real-time Analysis Interactive Lab (GRAIL), Motek Medical B.V, the Netherlands). The treadmill speed was regulated by a PD controller, with position dependent differential gain and additional correction for deliberate acceleration and deceleration. After a habituation period of about 10 min, subjects walked for 3 minutes first at SP and next at FS. FS was set at the comfortable walking speed measured during SP. During the last minute spatio-temporal data and kinematics were collected. An optoelectronics Vicon system was used to measure 25 markers. The HBM model was used for joint kinematics calculation [3]. Spatiotemporal parameters (walking speed, stride time and length, and step width) were based on kinematic data, both mean and within trial variation were calculated for each subject. The difference in joint kinematics between SF and FS was expressed as the average offset and the root mean square (RMS) corrected for the offset, thus indicating a difference in pattern. The effect of SP versus FS was evaluated using paired t-tests with multiple comparison correction.

RESULTS

Walking speed varied considerably over time during SP (0.07±0.01m/s variation) compared to FS (0.06±0.01 m/s; p=0.003). The kinematics were the same between SP and FS, except for a slight decrease in ankle flexion of 0.5° RMSE during SP (right: p<0.001, left: p=0.001) and hip flexion of 0.4° RMSE (left: p<0.001).

DISCUSSION & CONCLUSIONS

The results show that the variability of walking speed is increased during walking in SP mode. This could indicate that self-paced walking on a treadmill allows for more natural variation than constraint FS treadmill walking. The kinematic differences in hip and knee range of motion are clinically not significant. Therefore, SP seems a good experimental alternative to simulate over ground walking in clinical gait analysis. Additionally, the application of SP also allows for studying fatiguing and gait variability during gait. Future research should focus on whether SP better resembles over ground walking than FS treadmill walking.

REFERENCES

[1] Riley *et al*., Gait and Posture 26 (2007) 17-24

[2] Matsas *et al*., Gait and Posture 11 (2000) 46-53

[3] van den Bogert *et al*., *submitted*

BILATERAL LOWER EXTREMITY STIFFNESS DURING TRANSITION FROM STAIR DESCENT TO LEVEL WALKING IN UNILATERAL TOTAL HIP ARTHROPLASTY PATIENTS AND CONTROLS

Vassilios Vardaxis[1], Laura Covill[1], Leah Koepp[1], John Nettrour[2] and Craig Mahoney[2]

[1]Des Moines University, Doctor of Physical Therapy, Des Moines, IA, USA
[2]IOWA ORTHO, Orthopaedic Surgery, Des Moines, IA, USA

INTRODUCTION

For elderly individuals, stair descent can be challenging. It requires adequate visualization as well as proper kinesthetic feedback and regulation of joint stiffness. For patients with end stage hip osteoarthritis or post total hip arthroplasty (THA) the lost of ROM, strength and proprioception can make this task daunting. We evaluated differences in leg load and stiffness during transition from stair descent to level walking with subjects pre and post THA to age matched controls.

PATIENTS/MATERIALS and METHODS

Kinematic and kinetic data were collected while descending stairs on 12 THA patients and 7 controls before surgery and 3, and 6 months post-surgery. A six inch step height stair case was positioned adjacent to a floor imbedded force platform along the gait lab walkway. As subjects descended they would land on the force place and transition to walking forward. Five good trials per leg were recorded. A good trial consisted of stepping off the last step of the stairs with either leg, landing clearly on the force plate and stepping off the plate with the trailing leg. The lower extremity modeled as a linear spring[2,3], defined as the anatomical structure between the COP and the contralateral ASIS (CASIS). The lower extremity stiffness ($BW \bullet L^{-1}$), during landing (from the time of initial contact to the time of maximum shortening of the linear length of the leg), was computed from the slope of the load-deformation curve for the lower extremity. The load-deformation curve was derived from the magnitude of the instantaneous 3D vector of the ground reaction force toward the CASIS plotted against the instantaneous length change of the lower extremity. The peak load (BW) and the loading rate ($BW \bullet s^{-1}$) were also determined during descent. Two-way repeated measures ANOVA and two sample t-test procedures were used to test for within and between group differences. The significant difference was set at $a<0.05$ (SPSS 18).

RESULTS

The THA patients showed significantly lower peak load (1.3±0.19 vs 1.47±0.15 BW), loading rate (7.02±1.41 vs 8.12±1.55 $BW \bullet s^{-1}$), and leg stiffness (14.16 ±2.50 vs. 16.27±2.76 $BW \bullet L^{-1}$), on the surgical versus the healthy leg side during descent. Six months post-surgery, all these parameters increased in magnitude for the surgical side, however only the peak load showed a significant time effect and the bilateral difference persisted. The patients exhibited lower load and stiffness characteristics on both legs with respect to controls (1.50±0.18 BW, 9.35±1.71 $BW \bullet s^{-1}$, and 17.0±0.94 $BW \bullet L^{-1}$ respectively), however, these differences were significant only for the surgical leg.

DISCUSSION & CONCLUSIONS

Contrary to our expectations, load and stiffness on the surgical side was found lower for the THA patients. To manage the load placed on the leading surgical leg during stair descent, the THA patients used a dual task strategy. They lowered the body weight first and then redirected the motion. The patients continued to use this strategy six months post surgery. Our findings can be used to guide and evaluate rehabilitation post THA.

REFERENCES

[1] Luepongsak et al, OSTEOARTHR CARTILAGE 2002;10:353-359
[2] Farley & Gonzalez, J BIOMECH 1996;29:181-186
[3] Hsu et al, J REHABIL RES DEV 2007;3:429-436

GAIT CHANGES IN PATIENTS AFTER JAW AND MANDIBLE RECONSTRUCTION WITH FIBULA AND ILIAC CREST BONE AND SOFT TISSUE GRAFTS

Malgorzata Syczewska[1], Monika Kirwil[2] and Krzysztof Krajewski[2]

[1]The Children's Memorial Health Institute, Paediatric Rehabilitation, Warszawa, Poland
[2]Cancer Center M. Sklodowska-Curie Memorial Institute, Head and Neck Cancer, Warszawa, Poland

INTRODUCTION

Patients with malignant tumours of the jaw region require surgical removal of the tumour and reconstruction of the jaw bone and soft tissues. The grafts are taken either from lower leg (fibula) or pelvis (iliac crest). The removal of bones and tissues from the locomotor apparatus can impair the gait and with prolonged survival of these patients could influence quality of their life. To our knowledge this aspect of reconstructive surgery has not been investigated in detail. The aim of this paper is to assess how the localization of bone and soft tissues graft influences the gait pattern of these patients. When the surgeons have a choice from which place the graft can be taken, results of presented analysis could minimize the side effects of the procedure.

PATIENTS/MATERIALS and METHODS

Patients: 26 patients participated in the study. In 16 patients the bone and soft tissue grafts were taken from lower leg ("free fibula flap group" - FFFG), in 10 from pelvis ("iliac crest flap group" - ICFG) .

Methods: Patients underwent 3 instrumented gait analyses: before surgery, 2 to 4 month after the surgery, and 4 to 8 months after the surgery. The gait analysis was performed first using 6 camera VICON460 and later 12 camera VICON MX system. The spatio-temporal and kinematic data were extracted from the Polygon reports (based on averaged 6 trials), Gillette Gait Index was calculated [1], and data were analysed using MedCalc software. The analysis was performed separately for operated and non-operated side

RESULTS

The gait pattern changed after the surgery in both groups of patients, and remained changed in the last evaluation.

The gait changes in FFFG were: diminished gait speed in second and third evaluation, increased Gillette Gait Index in second and third evaluation in non-operated limb.

The gait changes in ICFG were: increased stance phase in non-operated limb in second and third evaluation, decreased cadence, decreased hip range in both legs, decreased knee range in operated limb, increased plantar flexion in swing phase in both legs. The changes were more pronounced in second evaluation than in the third one.

DISCUSSION & CONCLUSIONS

Surprisingly, the gait pattern changed more in the ICFG than in the FFF.

The increased Gillette Gait Index of non-affected side in FFFG could indicate, that patients introduced compensatory mechanisms on this side which helped them to cope with surgery effects.

In ICF some changes were due to compensatory mechanisms: increased stance phase in non-operated limb indicated the weight shift towards non-operated side. The decreased cadence and increased plantar flexion in both legs could indicate the generalized weakness. This plantar flexion together with decreased knee range in affected limb could increase fall risk in this group.

The shortcoming of this study is limited number of patients. Nevertheless, these preliminary results indicate, that the patients in FFFG have less problems with gait after operation.

ACKNOWLEDGEMENT

The study was supported by the research grant **NN403397039**of Polish Ministry of Sciences. The up-grade of the VICON system, was co-financed by ERDF (EU Structural Funds) project POIG.02.01.00-14-059/09.

REFERENCES

[1] L.M.Schutte et al., Gait & Posture 2000; 11: 25 - 31

GAIT ASSYMETRY AND TRUNK TORSION IN SCOLIOTIC GIRLS

Gerlinde Lenaerts[1], Dora Vegvari[1], Gabor Grosz[1], George Szoke[1] and Tamas Terebessy[1]

[1]Semmelweis University, Department of Orthopaedics, Budapest, Hungary

INTRODUCTION

The present study shows preliminary results on asymmetry in gait kinematics in subjects with idiopathic scoliosis compared to normal data. Furthermore, a new method is proposed to analyze the effect of spinal deformation on upper and lower trunk motion during gait.

PATIENTS/MATERIALS and METHODS

6 girls (mean age 13 ± 3) with scoliosis and 6 age matched normal subjects were included in this study. Type of scoliosis, Cobb angle and spinal rotation [1] were derived from digitized radiographs. All subjects performed a full body 3D gait analysis (Vicon Oxford Metrics) with a PlugInGait marker protocol. Maximum and minimum values and an asymmetry index (AI) [2] were calculated for the kinematic data in the relevant phases of the gait cycle. Motion of upper and lower trunk was defined by a vector pointing from the C7 to the clavicula marker and a vector pointing from T10 towards to the sternum marker. Based on these vectors the forward – backward bending and rotation from the upper trunk with respect to lower trunk and pelvis, and from the lower trunk with respect to the pelvis were analyzed. Furthermore, the torsional offset (TO) [2] of upper trunk with respect to lower trunk and pelvis and TO of lower trunk with respect to pelvis were calculated in the different phases of the gait cycle.

RESULTS

In the scoliosis group, mean Cobb angle was 26.03° ± 7.14 and mean spinal rotation was 22.77% ± 6.79. Sagital plane kinematics were within normal ranges at the ankle, knee and hip. High AI was found for frontal and transverse plane kinematics. In loading respons, AI for peak pelvis obliquity and peak hip exorotation in the scoliotic group was 13.39% and 49.83% respectively, compared to -16.58 % and -7.6% in the control group. In pre-swing, AI for peak pelvis exorotation was -67.39% in the scoliotic group compared to 7.26% in the control group. In swing AI for peak hip abduction was -10.90% in the scoliotic group compared to -1.68% in the control group. Upper to lower trunk rotation was continuously clockwise in the scoliosis group while in the control group the rotation was symmetric. Upper trunk to pelvis motion showed a bending of 4.5° in the scoliosis group and 32.3° in the control group. Rotation was similar in both groups. Lower trunk to pelvis motion was similar in both groups with 3-4° of bending and 11.5-12° of rotation switching clockwise to anti-clockwise during the gait cycle, but the switch occurred later in the gait cycle in the scoliotic group.

DISCUSSION & CONCLUSIONS

AI up to 14% are reported in normal subjects [2]. We found high AI for frontal and transverse plane motion compared to normal data, which can be related to the spinal deformation in these planes. An excessive pelvic clockwise rotation coincides with an excessive anticlockwise torsion of the upper trunk. Compensatory hip rotation was found to align the legs into the walking direction. The lack of bending of the upper trunk and the delay in switch in rotation of the lower trunk with respect to the pelvis might be due to the rotational deformity and rigidity of the scoliotic spine. Insight in how different parts of the trunk act during gait in subjects with scoliosis will enhance the understanding of the pathology and will provide information for optimized treatment. Therefore, further research on a larger population including kinetic analysis will be performed.

REFERENCES

[1] Vrtovec et al. Eur Spine J (2009) 18:1079–1090.

[2] Kramers-de Quervain et al. Eur Spine J (2004) 13 : 449–456

GAIT DEVIATIONS IN PATIENTS OPERATED ON BLADDER EXTROPHY

Maurizio Petrarca[1], Antonio Zaccara[2], Sacha Carniel[1], Armando Marciano[2], Gessica Della Bella[3], Paolo Caione[2] and Enrico Castelli[1]

[1]"Bambino Gesù" Children's Hospital, IRCCS, Movement Analysis and Robotic Laboratory (MARLab) - Pediatric Neuro-Rehabilitation Division, Rome, Italy
[2]"Bambino Gesù" Children's Hospital, IRCCS, Department of Urology and Nephrology, Rome, Italy
[3]"Bambino Gesù" Children's Hospital, IRCCS, Pediatric Neuro-Rehabilitation Division, Rome, Italy

INTRODUCTION

The role of bony pelvic anomalies in bladder exstrophy is long established and has generated many papers addressing walking problems, biomechanical and kinematic gait analysis [1, 2, 3]. However, a direct kinetic gait evaluation has never been performed.

PATIENTS/MATERIALS and METHODS

Nineteen patients with bladder exstrophy, age 14±8 years, were enrolled in the present gait analysis study. Gait analysis differences between patients with exstrophy and fifteen age-matched controls and between patients that received pelvic osteotomy (6 patients) and those that did not (13 patients) were analyzed. Maximum and minimum kinematic and kinetic values on sagittal plane were collected on three gait cycles for each subject. Anova and Bonferroni post hoc tests were performed.

RESULTS

All the studied values revealed statistical significance except for the ankle one. Furthermore, no alterations were observed at the hip level, while pelvic anterior tilt values were lower in patients compared to the control group. Knee flexion values were higher in patients compared to controls. The knee maximum flexor moment values and the knee maximum power generation in early stance were higher in patients compared to controls, whereas both the maximum extensor moment and maximum power generation were lower in late stance. Comparison between patients who had undergone pelvic osteotomy and those who had not revealed that patients who had undergone osteotomy showed the greatest differences compared to controls.

DISCUSSION & CONCLUSIONS

In conclusion, walking in exstrophy patients is accomplished by reduced antiversion of the pelvis and shift of the knee joint towards flexion. This leads to increased cargo on the knee mainly during load response phase, and is more evident in patients undergoing osteotomy. Pelvic osteotomy do not improve gait function. Orthopedic assessment and gait analysis should be part of the multidisciplinary follow up. Kinetic changes should be detected early thereby prompting rehabilitative treatment in order to prevent knee joint and tendon diseases.

REFERENCES

1. Sponseller PD, *et al.* Anterior innominate osteotomy in repair of bladder exstrophy. J Bone and Joint Surg 2001; 83-A(2): 184-193.

2. Jani MM, *et al.* The hip in adults with classic bladder exstrophy: a biomechanical analysis. J Pediatric Orthop 2000; 20(3): 296-30.

3. Sutherland D, *et al*. Hip function and gait in patients treated for bladder exstrophy. J Pediatric Orthop 1994; 14(6):709-14.

COGNITIVE AND MOTOR DUAL-TASKING AFFECTS SPATIO-TEMPORAL GAIT CHARACTERISTICS IN SUBJECTS WITH PARKINSON'S DISEASE

Niklas Löfgren[1], David Conradsson[1, 2], Agneta Ståhle[1, 2], Erika Franzén[1, 2]

[1]Karolinska Institutet, Department of neurobiology, care sciences and society, Stockholm, Sweden
[2]Karolinska University Hospital, Department of physical therapy, Stockholm, Sweden

INTRODUCTION

Impaired gait and falling is common in Parkinson´s disease (PD). Changes of gait characteristics when walking with an added task, i.e. dual-task (DT) of motor or cognitive character, has been linked to an increased risk of falling in elderly subjects as well as in PD populations [1, 2, 3]. In PD, prior studies have found gait during DT conditions to decrease velocity, cadence and step length, as well as to increase variability of spatio-temporal gait parameters [2]. However, although most studies have used a cognitive task, it remains unclear whether cognitive or motor DT conditions are most challenging in PD.

Hence, our aim was to compare spatio-temporal parameters during gait at comfortable speed, to gait with a dual-task of cognitive and motor character, respectively- in subjects with mild to moderate PD.

PATIENTS/MATERIALS and METHODS

34 subjects with mild to moderate PD (mean age: 71 ± 6 years, H&Y score: 1.5-3; disease duration: mean 5 ± 4 years) performed gait at their comfortable speed, and during a cognitive and motor DT, respectively, using an instrumented walkway system (GAITRite). During gait with a cognitive DT, the subjects were instructed to recite every second letter of the Swedish alphabet (following a randomized scheme), whereas the motor dual-task consisted of carrying a tray with a glass of water. Each task was performed 6 times. Between gait condition divergences were analyzed with repeated measurements analysis of variance and significant main effects were explored with Tukey HSD post-hoc test.

RESULTS

Walking with a cognitive DT showed decreased velocity, cadence, step length, swing phase, and increased step width ($p \leq 0.001$) in comparison to gait at comfortable speed, whereas walking with a motor DT only showed decreased step length and swing phase ($p \leq 0.034$). In addition, the step length variability increased while walking with a cognitive DT as compared to both gait at comfortable speed and with a motor task ($p \leq 0.045$).

DISCUSSION & CONCLUSIONS

The results of this study indicate that a cognitive task interferes more with walking than a motor task. However, studies controlling varied task difficulty have suggested more complex tasks to accentuate gait interference [4], which may indicate that the cognitive task we used were more complex than the motor task. Nevertheless, these results indicate that both cognitive and motor dual- tasks interfere with the gait pattern of subjects with mild to moderate PD. This may suggest a gait training regime, including both cognitive and motor dual-task conditions, to be beneficiary in subjects with PD. However, more studies are needed in this area.

REFERENCES

[1] Yogev-Seligmann, G., J.M. Hausdorff, and N. Giladi, The role of executive function and attention in gait. Mov Disord, 2008. 23(3): p. 329-42.

[2] Plotnik M, Giladi N, Dagan Y, Hausdorff JM. Postural instability and fall risk in Parkinson's disease: impaired dual tasking, pacing, and bilateral coordination of gait during the "ON" medication state. 2011 May;210(3-4):529-38.

[3] Beauchet, O., et al. Stops walking when talking: a predictor of falls in older adults? Eur J Neurol, 2009. 16(7): p. 786-95.

[4] Kelly VE, Eusterbrock AJ, Shumway-Cook A. A review of dual-task walking deficits in people with Parkinson's disease: motor and cognitive contributions, mechanisms, and clinical implications. Parkinsons Dis. 2012;2012:918719.

VERTEBRAL MOTIONS OF THE LUMBAR SPINE DURING GAIT

Adam Rozumalski[1], Bruce A. MacWilliams[2], Roy Wervey[1], Daryll C. Dykes[3], Tom F. Novacheck[1] and Michael H. Schwartz[1]

[1]Gillette Children's Specialty Healthcare, St. Paul, Minnesota, USA
[2]Shriners Hospitals for Children, Salt Lake City, Utah, USA
[3]Twin Cities Spine Center, Minneapolis, Minnesota, USA

INTRODUCTION

Only two studies have yet attempted to directly measure vertebral kinematics using in-dwelling bone pins [1,2]. In both studies, only two vertebrae were instrumented and neither study included gait. While several imaging based studies of spinal motion have been reported, measurement volume restrictions inherent to this modality are not conducive to gait applications. The goal of this study was to quantify the three dimensional motions of the lumbar vertebrea during gait via direct *in vivo* measurement.

PATIENTS/MATERIALS and METHODS

The methods for subject preparation and data collection have previously been described [3]. Briefly, subjects with no spinal pathology had two 1.55 mm Kirschner wires inserted into the spinous processes of L1, L2, L3, L4, L5 and S1. Motion capture marker triads were rigidly attached to the ends of the wires. Subjects then underwent spinal CT to enable anatomic registration between each vertebra and attached triad. Motion data was then collected as the subjects walked several times at self-selected speed.

RESULTS

The motion data were highly consistent between subjects, resulting in small standard deviations. The largest motions were in the frontal plane [Fig. 1]. Not shown are the flexion and axial rotation motions which were both extremely small at all levels.

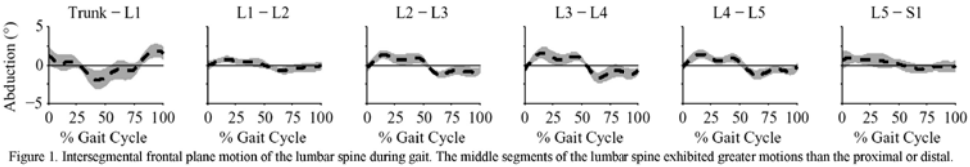


Figure 1. Intersegmental frontal plane motion of the lumbar spine during gait. The middle segments of the lumbar spine exhibited greater motions than the proximal or distal.

DISCUSSION & CONCLUSIONS

During gait, the lumbar spine acts as a distinct functional segment contributing abduction during stance and adduction during swing to balance the relative motions between the trunk and pelvis. The lumbar spine is also shown to act in concert with the thoracic spine. While the lumbar spine chiefly contributes frontal plane motion, the thoracic spine contributes the majority of the transverse plane motion. Both contribute flexion motion in an offset phase pattern.

REFERENCES

1. Steffen T, Rubin RK, Baramki HG, et al., *Spine*. 1997;22(2):156-166.
2. Dickey JP, Pierrynowski MR, Bednar DA, Yang SX., *Clin Biomech (Bristol, Avon)*. 2002;17(5):345-352.
3. Rozumalski A, Schwartz MH, Wervey R, et al., *Gait Posture*. 2008;28(3):378-384.

ESMAC

Saturday Sept 15

A2, Main Lecture Hall, Level 6

09.00-10.00	Session 7 Balance and Posture
10.00-10.30	Coffee by Main Lecture Hall
10.30-11.15	Keynote Lecture III Charlotte Häger
11.15-12.00	Session 8 Cerebral Palsy, Spasticity, Muscle and Gait
12.00-13.00	Awards and Closing

SATURDAY, SEPTEMBER 15, 2012

09.00 - 10.00	**SESSION 7 (A2)** **Balance and Posture** **Chairmen: Bettina Westhoff, Kristina Löwing**
O80 Houdijk, Han	Stepping into an unstable environment: gait adaptations in response to medio-lateral balance perturbations.
O81 Romkes, Jacqueline	Patients with diplegic cerebral palsy walking along a curved path
O82 Ballaz, Laurent	Visually guided weight-shifting in children with Cerebral Palsy
O83 Lidbeck, Cecilia	Crouched standing posture in bilateral cerebral palsy
O84 Stensdotter, Ann-Katrin	Postural control in psychotic patients in quiet standing with a dual task
O85 Biabanimoghadam, Mana	Core and lower extremity muscle recruitment pattern in response to an unexpected external perturbation in patients with Patellofemoral Pain Syndrome and healthy individuals

STEPPING INTO AN UNSTABLE ENVIRONMENT: GAIT ADAPTATIONS IN RESPONSE TO MEDIO-LATERAL BALANCE PERTURBATIONS.

Han Houdijk[1, 2], Laura Hak[2], Frans Steenbrink[3], Agali Mert[4], Peter Van der Wurf[4], Peter J Beek[2], Jaap H Van Dieen[2]

[1]Heliomare, Research and Developent, Wijk aan Zee, The Netherlands
[2]Research Institute MOVE, Faculty of Human Movement Sciences, VU University, Amsterdam, The Netherlands
[3]Motek Medical b.v., Amsterdam, The Netherlands
[4]Center for Augmented Motor Learning and Training, National Military Rehabilitation Center Aardenburg, Doorn, The Netherlands

INTRODUCTION

It has frequently been proposed that lowering walking speed is a strategy to decrease the probability of falling [1]. However, studies that investigated the effect of decreased walking speed on local dynamic stability (LDS) [1,5] and margins of stability (MoS) during gait [2-4] provide inconsistent results. The purpose of this study was to investigate whether and how healthy people adapt walking speed when confronted with balance perturbation, and to assess the effect of potential changes in walking speed and underlying step parameters on local dynamic stability and margins of stability.

PATIENTS/MATERIALS and METHODS

Nine healthy subjects walked in a Computer Assisted Rehabilitation ENvironment (CAREN), while continuous quasi-random medio-lateral (ML) translations of the walking surface at four different intensities were imposed. The self-paced option of the system was used, which enabled subjects to regulate their walking speed throughout the trials. The effect of the perturbations on walking speed, step length, step frequency and step width was measured. In addition, MoS in sideward and backward direction [2] and LDS in terms of the short-term Lyapunov exponent [5] were analysed.

RESULTS

No significant change in walking speed was found in response to the balance perturbations ($p=0.118$), but subjects made shorter, faster, and wider steps ($p<0.01$) with increasing perturbation intensity. Subjects became locally less stable ($p<0.01$) in response to perturbations, but increased their MoS in sideward ($p<0.01$) and backward ($p<0.01$) direction with increasing perturbation intensity.

DISCUSSION & CONCLUSIONS

The results of the present study indicate that the strategy of choice to cope with ML balance perturbations is not the reduction of walking speed, but rather a decrease of step length and increase of step frequency and step width. As a result of the proportional increase in step frequency and decrease in step length, walking speed stayed remarkably constant regardless of perturbation intensity. The adaptations in step parameters did not prevent LDS to decrease, but did cause a significant increase in MoS in backward and sideward direction, conform theoretical predictions. Because no falls occurred, the results suggest that people adapt their step parameters to create sufficiently wide margins of stability within which LDS can decrease without leading to an actual fall.

REFERENCES

1. Dingwell et al., J Biomech. 39(3): 444-52.
2. Hof AL et al., J Biomech 2005; 38(1): 1-8.
3. Hof AL et al., Gait Posture 2007; 25(2): 250-8.
4. Pai YC et al., J Biomech 1997; 30(4): 347-54.
5. Bruijn SM et al., J Biomech 2009; 42(10): 1506-12.

PATIENTS WITH DIPLEGIC CEREBRAL PALSY WALKING ALONG A CURVED PATH

Jacqueline Romkes[1]

[1]University Children's Hospital Basel, Laboratory for Movement Analysis, Basel, Switzerland

INTRODUCTION

Daily locomotion can be a challenge for children with diplegic cerebral palsy (diCP). Stair climbing, avoiding obstacles or walking on uneven ground are some of these challenges. Our walking path usually consists of frequent transitions from straight to curve walking and vice versa. This study investigates how children with diCP walk along a curve.

PATIENTS/MATERIALS and METHODS

13 children with diCP (without walking aids, 9 girls/5 boys, 14.3±2.0 yrs) and 13 healthy children (10 girls/3 boys, 14.8±1.7 yrs) participated in the study. All children walked a path with a 90° curve and a path with a 180° curve (figure 1). A Vicon 460 motion capture system was used to collect kinematic data of the "Vicon full body Plug in Gait marker model". Data analysis included calculating the centre of mass (CoM), path length and duration, step width, position of the traffic cone and of the lateral malleolus markers of three trials for each condition. The data were normally distributed and therefore the unpaired t-test was used for statistical comparison between the diCP and healthy children.

RESULTS

In all 13 healthy and in 7/13 diCP children the path of the CoM crossed that of the inner foot for the 180° curve (figure 2d), i.e. the CoM shifted outside the base of support. In 2/13 biCP children the CoM never left the base of support (figure 2a and 2c). At the 90° curve only 4/13 biCP children showed that the CoM shifted outside the base of support on all 3 trials. Furthermore, compared to the healthy children, the biCP children made a significantly longer path and needed more time to complete the curves (90° and 180°). Also the step width was significantly wider for the biCP.

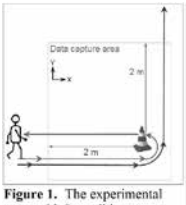


Figure 1. The experimental setup with 2 conditions: walking along a 90° curve and along a 180° curve.

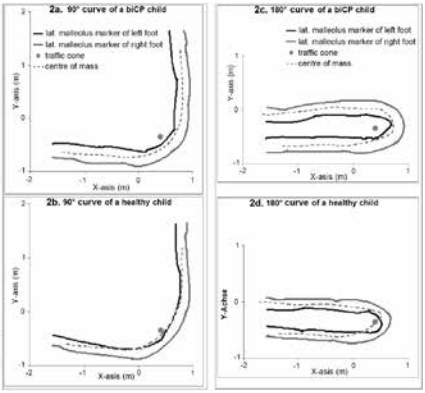


Figure 2. Projection of the positions of the lateral malleolus markers and the centre of mass on the floor of a biCP child and a healthy child during the two conditions at 90° and 180° curves.

DISCUSSION & CONCLUSIONS

Walking along a curved path requires a complex interplay between the different parts of our body [1] and a reduction in walking speed [2]. This study showed that children with biCP possibly compensate for their motor deficits by increasing the radius of the curve and by keeping the CoP within the base of support compared to healthy children. Together with a wider step width the biCP children increased balance control to manage to walk along curved paths.

REFERENCES

[1] Courtine and Schieppati (2003). Eur J Neurosci 18:177-90. [2] Vieilledent et al. (2001). Neurosci Lett 305:65-9.

VISUALLY GUIDED WEIGHT-SHIFTING IN CHILDREN WITH CEREBRAL PALSY

Laurent Ballaz[1], Maxime Robert[1] and Martin Lemay[1]

[1]Marie Enfant Rehabilitation Centre, Sainte-Justine UHC, Montreal, Canada

INTRODUCTION

The ability to control mediolateral weight-shifting is crucial for independent walking in different populations with motor disabilities including children with cerebral palsy (CP) [1, 2]. In real life, weight-shifting is usually done in response to a visual stimulus (e.g. attempting to avoid a person walking in the opposite direction). To our knowledge, weight-shifting in this more natural context has never been evaluated in children with CP. The aim of this study was (1) to assess visually guided weight-shifting ability in children with spastic diplegic CP and (2) to compare the postural control strategy adopted by children with CP and typically developing (TD) children during weight-shifting.

PATIENTS/MATERIALS and METHODS

Ten children with spastic diplegic CP (Gross Motor Function Classification System level I and II; age, 7-12 years) and ten TD age-matched children were tested in the present study. Participants played 10 min. with the skiing game on a commercially available active video game console (Wiifit™ board). Participants had to shift their weight from one leg to the other to steer the avatar in a slalom trajectory. Center of pressure (CoP) displacement as well as the trunk and lower limb movements were recorded during the last virtual downhill. The time spent with the trunk and lower limbs leaning in the same ML direction was calculated to quantify coordination between segments (see Figure 1). Maximal isometric lower limb strength (ankle, knee, and hip) and quiet standing postural control were also assessed.

RESULTS

Lower limb muscular strength was lower in children with CP compared to TD children (P<.05) whereas quiet standing parameters were not different between groups. The skiing game mainly resulted in ML CoP displacements (Table 1). Children with CP showed smaller ML CoP range and velocity as compared to TD children (P<.01) but larger trunk movements (P<.05). Trunk and lower extremity movements were less synchronized in children with CP (P<.05).

	CP	TD
CoP ML range (cm)	7.5(2.3)	12.5(2.9)**
CoP AP range (cm)	4.6(2.0)	5.8(2.6)
CoP Vmax ML (cm/s)	59.2(31.7)	103.2(35.7)**
CoP Vmax AP (cm/s)	45.7(36.0)	64.6(40.6)
Maximal lower extimity angle (°)	10.9(5.4)	8.1(1.8)
Lower extremity range (°)	16.7(8.0)	13.6(3.1)
Maximal trunk angle (°)	47.3(23.3)	29.0(16.2)*
Trunk range (°)	82.9(46.2)	45.9(23.9)*
Synchronous phase duration (%)	32.9(21.6)	57.4(18.4)*

Table 1: CoP displacement and kinematic parameters during weight-shifting

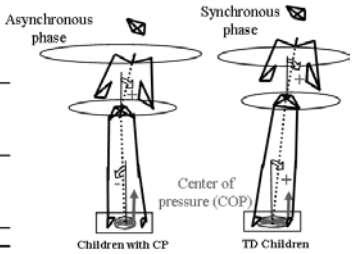


Figure 1: Postural strategy

DISCUSSION & CONCLUSIONS

Children with spastic diplegic CP showed impaired visually guided weight-shifting ability which can be explained by non-optimal postural movement coordination and possibly reduced lower limb muscular strength. The present project also showed the interest of using commercially available active video game to induce visually guided weight-shifting.

REFERENCES

[1] Liao HF et al. The relation between standing balance and walking function in children with spastic diplegic cerebral palsy. *Dev Med Child Neurol.* Feb 1997;39(2):106-112.

[2] Stackhouse et al. Gait initiation in children with cerebral palsy. *Gait & posture.* Jul 2007;26(2):301-308.

CROUCHED STANDING POSTURE IN BILATERAL CEREBRAL PALSY

Cecilia M Lidbeck[1], Elena Gutierrez-Farewik[2], Eva W Broström[1] and Åsa Bartonek[1]

[1]Karolinska Institutet, Department of Women's and Children's Health, Stockholm, Sweden
[2]KTH Mechanics, Royal Institute of Technology, Stockholm, Sweden

INTRODUCTION

In children with cerebral palsy (CP) motor functions such as standing and walking are affected by postural abnormalities, poor balance control, muscle weakness and biomechanical restrictions (1). Upper neuron syndrome with spasticity, fatigability and poor selective motor control are reported to contribute to movement disorders in CP (2). Recently secondary musculoskeletal problems and disturbances in perception have been added as factors influencing movement disorders (3). How and to which extent various factors influence standing posture is not described. The aim of this study was to describe standing posture in relation to joint restrictions in children with bilateral CP.

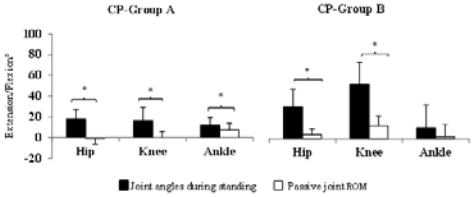
PATIENTS/MATERIALS and METHODS

Standing posture in 26 children with CP, mean age 11y (SD 3y), and 19 typically developing children, was recorded for 30 seconds with 3D motion analysis. Fifteen children with ability to stand without support were designated CP-Group A (GMFCS I-III), and 11 who needed support for standing CP-Group B (GMFCS III-IV). All children were tested with their habitual footwear. Passive joint range of motion (ROM) was measured with a goniometer. Lower limb contractures were defined as passive ROM less than neutral joint position.

RESULTS

Uni- or bilateral joint contractures were equally presented among the children in both CP groups A and B; in the hip (4 vs 7), the knee (6 vs 9), and in the ankle (2 vs 3). CP-Group B presented with significantly less passive joint ROM than CP-Group A in hip extension (-4°(SD 5°) vs 1°(SD 5°), p=0.022), knee extension (-12°(SD 10°) vs 0°(SD 6°), $p \leq 0.001$), and ankle dorsiflexion (2°(SD 13°) vs 7°(SD 7°), p=0.009) (Fig.1).

Children in both CP groups A and B stood with significantly more flexion than their passive joint ROM in the hip ($p \leq 0.001$ vs p=0.004 respectively), in the knee (p=0.003 vs p=0.003), and in the ankle in CP Group A (p=0.012 vs p=0.182) (Fig.1).



DISCUSSION & CONCLUSIONS

The flexed joint position during standing with respect to the passive joint extension ROM in both CP groups indicates that the children did not utilize their possible joint extension ROM during upright standing. Knee flexor spasticity was observed in both groups and might have contributed to difficulties to erect their lower limbs. The large difference between the joint position in the unloaded and the upright positions, in particular in the children who needed support (CP-Group B), might also be interpreted as lower limb muscle weakness. Which factors contribute to the difficulties to align the body segments and maintain a stable body position with respect to gravity during standing in children with bilateral CP requires further exploration.

REFERENCES

(1) Woollacott and Crenna 2008 (2) Kerr et al. 2003 (3) Rosenbaum et al. 2007

POSTURAL CONTROL IN PSYCHOTIC PATIENTS IN QUIET STANDING WITH A DUAL TASK

Ann-Katrin Stensdotter[1], Anne Kristin Wanvik[1] and Håvard W Lorås[1]

[1]Sør-Trøndelag University College, Faculty of Health Education and Social Work, Physiotherapy, Trondheim, Norway

INTRODUCTION

Synergies in motor tasks co-exist with perceptual and cognitive functions, and postural control is affected by the parallel performance of a cognitive task. In healthy persons, a concurrent mental or verbal arithmetic task while controlling posture in quiet standing may reduce the area of center of pressure (CoP) but increase the frequency of directional changes. Verbalization due to concurrent control of posture and respiration may further increase the frequency in the CoP signal[1]. In subjects with a psychotic condition, anomalous cognitive and motor performance is observed that may reflect a failure to correctly integrate different sources of information. Evidence of deficits in postural control in quiet standing may be explained by insufficient ability to process sensory information. Addition of a cognitive task may further impact the ability to sustain postural equilibrium. Our hypothesis was that the addition of a cognitive and verbal task during quiet standing would increase postural sway and decrease corrective ankle torque and CoP frequency in patients. In contrast, healthy subjects were hypothesized to display reduced sway and intensified corrective ankle torque and CoP frequency.

PATIENTS/MATERIALS and METHODS

Twelve patients in a locked psychiatric ward admitted after first incidence of psychotic illness and 18 healthy subjects participated (mean age 24 ±5years). Subjects maintained quite standing on firm surface with eyes open with and without a concurrent verbal arithmetic task. Kinetics (Good Balance, Metitur Ltd, Finland) and whole body kinematics (Qualisys, Sweden) were collected for 60s for each condition. Center of mass (CoM) was calculated with Visual 3D (C-motion, USA) and comprised the slow component (postural sway). Structural analyses of the CoP signal were made for the fast component (ankle torque) by subtracting the CoM signal from the CoP signal[2]. The mean power frequency (MPF) of CoP was estimated by spectral analysis (Fourier) using the Welch's periodogram method[3]. Statistics were performed with repeated measures ANOVA (SPSS 19).

RESULTS

Postural sway and ankle torque were larger in patients at baseline, whereas MPF was similar to healthy subjects. With addition of a cognitive task, the magnitude of the fast component increased in both groups, with larger effect in patients. MPF increased similarly in both groups. There was no effect on the slow component. The fast component was proportionally larger than MPF in patients compared to healthy subjects in both conditions.

DISCUSSION & CONCLUSIONS

Our hypothesis was rejected. Instead we found that in response to the cognitive task patients, similarly to healthy subjects, retained the degree of postural sway and upgraded ankle torque and the intensity of directional shifts of correcting forces. However, both at baseline and with the cognitive task, patients displayed greater ankle torques, but did not display corresponding increased frequency of shifts of directional forces. Thus, patients swayed more than healthy subjects in both conditions due to mismatch between the fast component and MPF. Notably, postural control is anticipatory and not reactive.

REFERENCES

1. Dault MC, Yardley L, Frank JS. Does articulation contribute to modifications of postural control during dual-task paradigms? *Brain Res Cogn Brain Res*. 2003;16:434-440.
2. Duarte M, Zatsiorsky VM. On the fractal properties of natural human standing. *Neurosci Lett*. 2000;283:173-176.
3. Duarte M, Freitas SM. Revision of posturography based on force plate for balance evaluation. *Rev Bras Fisioter*. 2010;14:183-192.

CORE AND LOWER EXTREMITY MUSCLE RECRUITMENT PATTERN IN RESPONSE TO AN UNEXPECTED EXTERNAL PERTURBATION IN PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME AND HEALTHY INDIVIDUALS

Mana Biabanimoghaddam[1], Zahra Rojhani shirazi[1] and Alireza Motealleh[1]

[1]shiraz university of medical sciences, physical therapy department, shiraz, iran

INTRODUCTION

Functions are generally developed through the kinetic chain and require the efficient subsequence in muscles activation [1]. Deficit in neuromuscular control may be a contributing factor to the development of musculoskeletal disorders such as patellofemoral pain syndrome (pfps), which is a common and clinically complicated condition [2,3]. The aim of the present study was to compare the electromyographic firing pattern of the core and lower extremity muscles in response to sudden lateral perturbation in patients with pfps and healthy subjects.

PATIENTS/MATERIALS and METHODS

27 females with pfp and 27 healthy controls with no history of knee injuries participated in this interventional study. Subjects were instrumented with EMG electrodes on the erector spine, transverse abdominis and internal oblique, gluteus medius, tensor fascia lata, vastus lateralis, vastus medialis obliqus and peroneus longus. Onsets of electromyographic activation of the selected muscles were measured by surface EMG, ME6000 16-channel system(Kistler Ltd.Finland) in response to an unexpected mediolateral pelvic perturbation in standing position. Independent t-test was used to compare each muscle's mean onset latency between groups. The muscle activation pattern in each group was analyzed by a non-parametric friedman test and wilcoxon signed ranks test.

RESULTS

Females with patellofemoral pain syndrome demonstrated delayed onset of gluteus medius($p= 0.025$), vastus medialis obliqus($p=0.033$) and vastus lateralis($p= 0.024$) and earlier activation of internal oblique and transverse abdominis($p< 0.001$) and also erector spine ($p = 0.001$), than the control group. The muscles indicated significantly different activation time within groups($p< 0.001$).

DISCUSSION & CONCLUSIONS

This study provides evidence that neuromuscular control and muscle activation pattern are different between individuals with pfps and healthy subjects. It appears that evaluating the entire kinetic chain rather than focusing on the action of a particular segment is necessary to identify the compensatory strategies of control system.

REFERENCES

[1] Kibler Wb Et Al (2008). Sports Medicine. 36(3):189-98.

[2] Fagan V Et Al (2008). British Journal Of Sports Medicine. 42(10):789.

[3] Bolgla La Et Al (2010). Journal Of Electromyography And Kinesiology. 20(1):142-7.

10.00 - 10.30	**COFFEE BY MAIN LECTURE HALL**
10.30 - 11.00	**KEYNOTE SPEAKER III, Charlotte Häger, Professor, RPT, Umeå University, Umeå, Sweden** How may various movement laboratory techniques be used to increase the understanding of human sensorimotor control and address questions of clinical relevance? (A2)

Curriculum Vitae of Charlotte Häger

Professor Häger is physiotherapist and professor at the Section of Physiotherapy, Umeå university, Sweden. Professor Häger obtained a PhD in neurophysiology in 1995. Her thesis was neuroscientific basic research in sensory physiology of direct importance for the understanding of human sensorimotor mechanisms related to the manipulative functions of the hand and the ability to reach and grasp for objects. She has since extended her research to include related clinical questions and projects involving also other types of sensorimotor tasks, like postural function in knee patients and neck function in patients with neck and back pain.

Studies particularly address pathophysiological issues and involve adult patients with neurological or musculoskeletal disorders as well as children with sensorimotor deficits, but also studies of the development of normal motor function in children of various ages. These latter studies serve as norms to be used as comparisons in diagnosing and treating children with motor dysfunction.

Abstract

How may various movement laboratory techniques be used to increase the understanding of human sensorimotor control and address questions of clinical relevance?

Sensorimotor control of human movement is complicated and difficult to study, especially in clinical conditions. The underlying mechanisms for certain movement behaviour are often unknown, and it may be difficult to identify which specific sensory input that drives the movement and what processes that determine the movement outcome whether it is going to be successful or not, an understanding that would seem essential in re-/habilitation. This lecture will describe research where various methodologies in movement laboratories are used to study human motor control and nerve-muscle function.

The research projects address basic understanding of human movement function as well as evaluation of clinical intervention with implications for rehabilitation and with regard to function of the upper as well as the lower extremity. The studies involve subjects with musculoskeletal conditions such as patellofemoral pain and anterior cruciate ligament injury, but also neurological diagnoses like spinal cord injury, stroke and cerebral palsy. Functional movement tasks examined include stair walking, balance tests and different jumps that are commonly used in the clinics for evaluation of knee rehabilitation for example after anterior cruciate ligament injury.

Other projects address hand and arm function in stroke patients, evaluated with detailed movement analysis, or evaluate training with interactive games in children with cerebral palsy. Intraneural microstimulation of single motor axons has been used to examine nerve-muscle function in subjects paralysed by cervical spinal cord injury (SCI). The results show that these methods help to capture pathological differences in movement patterns and leads to knowledge that increases the understanding of movement disorders and may guide treatment and rehabilitation.

The long term goal of the research is to improve the health of patients by building a better theoretical foundation for rehabilitation with particular emphasis on sensorimotor control.

11.00 - 12.30	**SESSION 8 (A2)** **Cerebral Palsy Spasticity, Muscle, Gait** **Chairmen: Guy Molenaers, Meta N Eek**
O86 Boulay, Christophe	A new therapeutic target in equinus: Botulinum toxin injection (Dysport®) in Peroneus Longus
O87 Bar-On, Lynn	Objective quantification of the effect of botulinum toxin-a injections in the medial hamstrings in children with spastic Cerebral Palsy
O88 Klotz, Matthias	The influence of botulinum a toxin injections into gastrocsoleus on genu recurvatum in children with Spastic Diplegia
O89 Nyström Eek, Meta	Muscle strength after BTX injection in children with Cerebral Palsy

O90 van Drongelen, Stefan	The good and the bad one: gait-patterns in twins with Cerebral Palsy
O91 Dadashi, Farzin	Multiscale entropy based features for spasticity diagnoses
O92 Desloovere, Kaat	Comparison between different on- and offset detection methods for muscle activity during gait for children with Cerebral Palsy and typical developing children
O93 Wambacq, Hans	Probabilistic onset detection based on multiple strides
O94 Brunner, Reinald	Increased femoral anteversion is not associated with internal hip rotation gait in Cerebral Palsy

A NEW THERAPEUTIC TARGET IN EQUINUS: BOTULINUM TOXIN INJECTION (DYSPORT®) IN PERONEUS LONGUS

Christophe BOULAY[1], Michel Jacquemier[1], Vincent Pomero[1], Yann Glard[1], Elisabeth Castanier[1], Guillaume Authier[1], Gérard Bollini[1], Brigitte Chabrol[1], Jean-Luc Jouve[1] and Elke Viehweger[1]

[1]CHU Timone enfants, Aix-Marseille Univ, Gait lab, pediatric department, Marseille, France

INTRODUCTION

In young hemiplegic children (< 6 years) an overactivity with abnormal timing EMG of Peroneus Longus (PL) is described in dynamic equinus with hindfoot valgus by Boulay et al. (1) . This study would suggest that the PL could be a new therapeutic target: the treatment of PL by Botulinum Toxin injections would be able to prevent onset of joint deformity (pes plano valgus and mid foot break). This hypothesis is tested in a retrospective study. The clinical and radiological efficiency of the Botulinum toxin in PL is assessed.

PATIENTS/MATERIALS and METHODS

Sixteen hemiplegic CP children GMFCS 1 (3.25 yrs± 1.5) with abnormal timing EMG of PL and dynamic equinus with hindfoot valgus (1) were treated by a botulinum toxin injection (Dysport®, Ipsen) only in PL (between 6 and 7 ui/kg). Goniometric assessment of ankle passive dorsiflexion and foot morphology in a standing position had been collected. Radiological foot parameters measured forefoot pronation (metatarsal stacking angle), midfoot planus (lateral talo-first metatarsal or Meary angle) and equinovalgus hind foot (Meary incidence of postero-anterior ankle, calcaneal pitch and talocalcaneal angles) (2, 3). The intra and extra-observers variability are assessed and compared with those of the literature (2, 3). These parameters are validated in the healthy and hemiplegic children (2, 3). A paired T-test compared for each angle the pre and post-toxin measurement.

RESULTS

The ankle passive dorsiflexion was 13°±12° (pre-toxin) vs 12°±10° (post-toxin) ($p<0.05$). The parameters variability was < 3°. The parameters described between pre-toxin vs normal data (2, 3) : calcaneal pitch angle (7.6° vs 17° $p<0.001$), talocalcaneal angle (54.8° vs 49° $p<0.05$), lateral talo-first metatarsal angle (28.7° vs 13° $p<0.001$) and metatarsal stacking angle (1.9° vs 8° $p<0.001$). There was a non-significative difference, between pre vs post-toxin, for the calcaneal pitch angle (7.6° vs 9° $p<0.05$) and the postero-anterior ankle angle (14.2° vs 14.7° $p<0.05$). There was a significative difference, between pre vs post-toxin, for the talocalcaneal angle (54.8° vs 46° $p<0.001$), the lateral talo-first metatarsal angle (28.7° vs 17.7° $p<0.01$) and the metatarsal stacking angle (1.9° vs 7.2° $p<0.001$).

DISCUSSION & CONCLUSIONS

There was no triceps surae contracture. The toxin injections were safety and did not provoke a talus. There was a clinical improvement on hind, mid and forefoot. Before toxin injections vs normative data, the radios showed a hindfoot valgus with midfoot planus and a forefoot pronation. After toxin injections, in correlation with clinic and the literature (2, 3), X-rays described a significative decrease of hindfoot valgus and midfoot planus and an absence of forefoot pronation. Botulinum toxin in PL had therapeutic actions on fore and midfoot and on the talus (hindfoot); there was no modification on the calcaneus. Thus PL could be a new therapeutic target for Botulinum Toxin in pes plano valgus and mid foot break in young CP children before the onset of midfoot break deformity. Prospective study had to confirm these data in a large population.

REFERENCES

1. Boulay C, Pomero V, Viehweger E et al. Dynamic equinus with hindfoot valgus in children with hemiplegia. Gait Posture. Available online. 15 March 2012

2. Davids JR, Gibson TW, Pugh LI. Quantitative segmental analysis of weight-bearing radiographs of the foot and ankle for children: normal alignment. J Pediatr Orthop. 2005 Nov-Dec;25(6):769-76.

3. Westberry DE, Davids JR, Roush TF, Pugh LI. Qualitative versus quantitative radiographic analysis of foot deformities in children with hemiplegic cerebral palsy. J Pediatr Orthop. 2008 Apr-May;28(3):359-65.

OBJECTIVE QUANTIFICATION OF THE EFFECT OF BOTULINUM TOXIN-A INJECTIONS IN THE MEDIAL HAMSTRINGS IN CHILDREN WITH SPASTIC CEREBRAL PALSY

Lynn Bar-On[1], Erwin Aertbeliën[2], Catherine Huenaerts[3], Guy Molenaers[3, 1], Anja Van Campenhout[3], Britt Vandendoorent[1], Kaat Desloovere[1, 3]

[1]KU Leuven, Rehabilitation Sciences, Leuven, Belgium
[2]KU Leuven, Mechanical Engineering , Leuven, Belgium
[3]University Hospital Pellenberg, CMAL, Pellenberg, Belgium

INTRODUCTION

Spasticity is the most common movement disorder in children with cerebral palsy (CP) and is often treated with Botulinum Toxin A (BTX-A). Despite this, most clinical tools for measuring spasticity are subjective and are not sufficiently reliable[1]. The aim of the study was to evaluate the effect of BTX-A injections in the medial hamstrings (MEH) by means of objective, multidimensional, spasticity-sensitive parameters in children with CP.

PATIENTS/MATERIALS and METHODS

Nineteen children with spastic CP (13 bilateral, 6 unilateral involvement, 7.2±3.1yrs, 10 males) were treated with multilevel BTX-A injections. Twenty three MEH muscles, injected with an average of 4.3±1.1 U/Kg botox®, were selected for objective assessment. Measurements were carried out 14.5±24.4 days before injection and 43.4±16.4 days after injection. Muscle activity was measured with surface electromyography (sEMG), joint angle characteristics with inertial measurement units, and reactive resistance with a 6 DoF torque-sensor. The MEH was passively stretched by a therapist who moved the knee joint through the full ROM during 5 seconds (V1) and as fast as possible (V2). Outcome parameters included the change in root mean square EMG (RMS-EMG) and in work (J) between V1 and V2.Work was defined as the area underneath the torque-position graph. Furthermore, the angle of catch (AOC), expressed as a percentage of the available range of motion, was determined. AOC was defined as the angle corresponding to the first minimum power after maximum power. Pre- and post- treatment measurements were compared using the Wilcoxon Matched Pairs Test (p<0.05).

RESULTS

Table 1 summarizes the pre- and post-treatment group results. RMS-EMG and work decreased significantly post treatment. The AOC occurred significantly later in the range of motion.

Table 1: Median and interquartile range (IQR) values of parameters pre- and post-treatment with BTX-A.

	PRE		POST		
	Median	IQR	Median	IQR	*p value*
RMS-EMG (mv)	0.014	0.012	0.006	0.013	0.026
Work (J)	3.223	4.358	2.326	3.822	0.038
AOC (%)	85.82	16.12	94.64	11.97	p<0.01

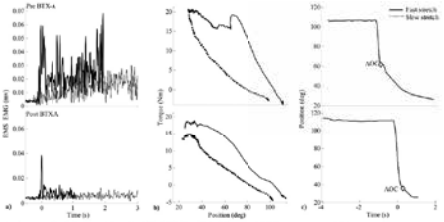


Figure 1: Example of **a)** RMS EMG-time, **b)** torque-position and **c)** position-time graphs during slow and fast stretches pre- (top row) and pos:- (bottom row) BTX-A. Angle of Catch (AOC) is shown.

DISCUSSION & CONCLUSIONS

The proposed method provides a set of sensitive parameters that can be used to objectively measure the effect of treatment on spasticity in the MEH of children with spastic CP. The large variance in results suggests that children react differently to BTX-A.

REFERENCES

1. Fleuren JF.et al. 2010;119:2329-37.2.

THE INFLUENCE OF BOTULINUM A TOXIN INJECTIONS INTO GASTROCSOLEUS ON GENU RECURVATUM IN CHILDREN WITH SPASTIC DIPLEGIA

Matthias CM Klotz[1], Sebastian I. Wolf[1], Daniel Heitzmann[1], Frank Braatz[1] and Thomas Dreher[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

The plantar flexion - knee extension – couple is a well-accepted model explaining the influence of equinus deformity on knee extension in stance phase in patients with cerebral palsy. Hence equinus may lead to genu recurvatum (GR) [1]. Several studies reported the outcome of range of motion, kinematics and kinetics of the ankle after Botulinum toxin A (BtA) injection or calf muscles lengthening [2,3]. Since the gastrocnemius muscle is biarticular, the injection may also have a direct influence on the knee. However, investigations addressing the influence of surgical treatment on GR are rare and those analyzing the influence of BtA on GR are missing. The aim our study was to investigate if BtA-injections in the calf muscles influence a coexisting GR.

PATIENTS/MATERIALS and METHODS

13 patients (26 limbs) with spastic diplegic CP showing equinus and coexisting primary GR (defined as knee hyper-extension > 1SD from age-matched reference group during stance phase, no previous surgery or BtA- intervention regarding the lower extremity) which were treated with BtA-injections into the calf muscles (gastrocnemius ± soleus) were included. Evaluations were done before (E0), 6 (E1) and 18 (E2) weeks after intervention using three-dimensional gait analysis according to a standardized protocol. Mean age at intervention was 4.6 years (range: 2-7y). The BtA-injections were performed under standardized conditions by skilled staff. The administered dose was determined according to the clinical approved, weight-adapted protocol. Basic statistical analysis was done ($p<0.05$).

RESULTS

Maximum ankle dorsiflexion was significantly increased from -0.5±12.8 degrees before to 6.5±13.5 degrees at E1. There was a slight deterioration to 3.9 degrees 18 weeks after the BtA-injections. Minimum knee flexion in stance did not change significantly between E0 and E1, but there was a slight but not significant improvement of knee hyperextension during stance phase of 4.6 degrees between baseline and 18 weeks after BtA-injection.

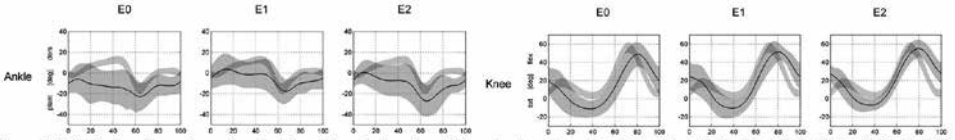


Figure 1: Sagittal plane kinematic graphs of ankle and knee before, 6 and 18 weeks after intervention. Mean value of all subject limbs (blue solid line); 1 SD (blue lucent area); age-matched reference group (grey area).

DISCUSSION & CONCLUSIONS

BtA-injection into the calf muscles is commonly accepted for the treatment of dynamic equinus in CP children. Corroborating the findings of previous studies a significantly improved ankle dorsiflexion was found in our study [3]. Despite improvement of ankle dorsiflexion, GR was not influenced 6 weeks after injection and only a slight reduction of GR was found after 18 weeks. However, manifest knee hyperextension (more that 1SD from norm) remained in most of the cases indicating that plantar-flexion knee-extension couple only partially influences GR. Other factors should be considered. Weakness of proximal gastrocnemius after BtA-injection could also have influenced the results.

REFERENCES

[1] Baddar A et al (2002). J Bone Joint Surg Am 84-A:736-44.

[2] Banks HH (1977). Clin Orthop Relat Res:70-76.

[3] Sutherland DH et al (1999). Gait Posture 10:1-9.

MUSCLE STRENGTH AFTER BTX INJECTION IN CHILDREN WITH CEREBRAL PALSY

Meta N Eek[1], Magnus Påhlman[2], Kate Himmelmann[2] and Berit Askljung[2]

[1]Queen Silvia Children's Hospital, Regional Rehabilitation Centre, Gothenburg, Sweden
[2]

INTRODUCTION

Spasticity is a common problem in children with cerebral palsy (CP), which can affect motor development negatively by hampering voluntary movement and cause muscle shortening. Since the 1990s, it has been possible to treat spasticity with injections of Botulinum toxin (BTX) that inhibits the transmission of nerve impulses to the muscle. The drug effect is usually maximal after 4-6 weeks and lasts about 3 months. By blocking nerve impulses to the muscle fibres the muscle is theoretically weakened. Muscle weakness has been reported in a couple of studies on treatment with BTX, although usually as comments and we have found only one study that has actually measured muscle strength [1]. In that study muscle strength had increased 24 weeks after injection. The reports are conflicting and it is not fully known how BTX affects voluntary muscle strength. Muscle weakness is common in children with CP and has been shown to correlate with walking ability [2]. With this in mind it is important not to make weak muscles even weaker with treatment.

PATIENTS/MATERIALS and METHODS

Children were recruited consecutively from the spasticity clinic at the Regional Rehabilitation centre in Gothenburg. So far 17 children with spastic CP have been included in the study, seven girls and ten boys, 4-13 years old, 16 at GMFCS I, one at level II. Twelve children had unilateral and five bilateral involvement. Measurement of muscle strength was made with a handheld device using the “make” technique. Lever arm for each muscle group was measured with a tape measure and torque was calculated (Nm), torque values were normalised to body weight (Nm/Kg). Muscle strength was compared before BTX, at maximum effect and when BTX has levelled off. Plantar flexor strength was evaluated for BTX injections in gastrocnemius muscles and knee flexor strength for hamstrings muscles. Not treated muscles served as control to treated muscle groups. Data was analysed with ANOVA repeated measures (SPSS).

RESULTS

Sixteen children had injections in one or both gastrocnemius muscles (20 legs) and seven children had injections in hamstrings muscles (10 legs). Before treatment there were no differences in muscle strength in muscles subject to BTX than muscles not in question for treatment. There was no difference in muscle strength between children with uni- or bilateral involvement. There were no significant differences in muscle strength 5.6 (3-12) weeks after injection. At follow up 4-7 months after, there was a slight increase in plantar flexor strength in children treated with BTX, but it did not reach statistical significance.

DISCUSSION & CONCLUSIONS

Voluntary force production in hamstrings and plantar flexor muscles was not affected by BTX treatment in this study. Adequate muscle strength is important to maintain the ability to walk and knowledge of how spasticity reduction treatments affect the muscle strength is necessary when selecting appropriate interventions, in order not to make motor performance more difficult. It is also important to know how muscle strength develops after various treatments to help inform parents and prognosticate future functioning.

REFERENCES

[1] Bjornson K, Hays R, Graubert C, Price R, Won F, McLaughlin JF, et al. Botulinum toxin for spasticity in children with cerebral palsy: a comprehensive evaluation. Pediatrics. 2007 Jul;120(1):49-58.

[2] Eek MN, Beckung E. Walking ability is related to muscle strength in children with cerebral palsy. Gait Posture. 2008 Oct;28(3):366-71

THE GOOD AND THE BAD ONE: GAIT-PATTERNS IN TWINS WITH CEREBRAL PALSY

Stefan van Drongelen[1], Thomas Dreher[1], Daniel Heitzmann[1] and Sebastian I Wolf[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

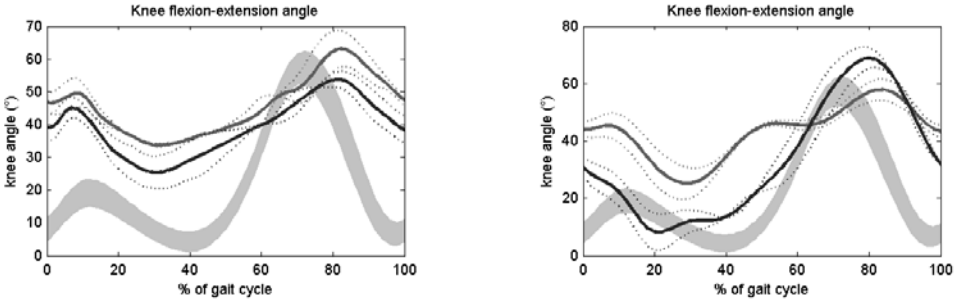
The incidence of twins being born with cerebral palsy (CP) is 0.9% [1]. Often twins show similarities in their overall gross motor function which also emerges in their gait pattern. Gait patterns in spastic motor disorders are determined by the inferior leg and can be expressed by the Gillette Gait Index (GGI). It is not known if the gait pathology is characterized predominantly by the disorder or by genetic dispositions. The aim of this study was to describe the gait pattern of twins with CP and to study how different or how equal their gait patterns are based on the GGI.

PATIENTS/MATERIALS and METHODS

In this retrospective study, data of 7 twin pairs (mean age: 9.3, SD: 2.0, 8 boys, 6 girls) with a spastic diplegia, who were seen preoperatively between 1996 and 2011, were analyzed. Patients underwent a standardized clinical exam and three-dimensional gait analysis. Gross Motor Function Classification System (GMFCS) score was taken from the medical records. Gait patterns were determined according to Rodda [2] and the Gillette Gait Index was calculated.

RESULTS

GMFCS was 2 (7 twins), 3 (4 twins) and missing in 3 twins. Gait pattern was determined as crouch gait in 16 legs, as jump knee in 12 legs. 12 subjects showed the same gait pattern in the left and the right leg. Two twin pairs had the same gait pattern in all legs. Based on video-documentation all twins could be categorized as the one twin of a pair with the good and as the one with the inferior gait pattern. Classification was not in accordance with the closest values of the GGI. Only one leg had the contralateral leg as the next equal. In one (quite similar) couple the GGI's of the inferior legs were closely related.



Figures 1-2: Sagittal knee angle for 2 twin pairs, illustrating the similarities and dissimilarities. Blue and red lines represent a twin; grey border represents norm data of 24 able-bodied children.

DISCUSSION & CONCLUSIONS

In twins with CP, most of the time gait patterns were found to be the same for both legs. GGI's were not better related between twins or between legs. Based on the GGI it seems that gait pathology is characterized predominantly by the traumatic disorder and not by genetic dispositions.

REFERENCES

[1] Yokoyama Y et al (1995). Int J Epidemiol 24:943-8.

[2] Rodda J et al (2004). J Bone Joint Surg Br. 2004 86:251-8.

MULTISCALE ENTROPY BASED FEATURES FOR SPASTICITY DIAGNOSES

Farzin Dadashi[1], Daisuke Negishi[1], Benoit Mariani[1], Christopher Newman[2], Aline Bourgeois[2] and Kamiar Aminian[1]

[1]École Polytechnique Fédéral de Lausanne, Laboratory of Movement Analysis and Measurement, Switzerland
[2]Lausanne University Hospital, Department of Pediatrics, Switzerland

INTRODUCTION

Spasticity is a motor neuron dysfunction which is associated with a velocity dependent increase of muscle tone (i.e. catch reflex) in response to the fast passive movement. The catch reflex affects the smoothness of the joint movement pattern. The multi-scale entropy (MSE) has been shown to be a promising tool to describe the fluctuations of physiologic signals [1]. In this study we used MSE as a feature to quantify the passive knee flexion-extension smoothness in order to discriminate different stages of pathology.

PATIENTS/MATERIALS and METHODS

Twelve spastic CP children (10.1±2.6 yrs; 37.2±14.9 kg; 131±12 cm; GMFCS range I-II; 10 hemiplegic, 2 diplegic) participated in the study. Two experienced examiners carried out three fast and slow passive muscle stretches of the hamstrings according to the test protocol in [2] on each subject. We used two inertial sensors, (Physilog®, 200 Hz, AGM, Switzerland) for tracking the angle between distal and proximal segments [2] and for labeling the patients based on fast (R1) and slow (R2) stretch ranges of motion on the Tardieu scale (TS) [3]. Using TS values the patients were labeled in two groups (R1-R2 <10° & 10°<R1-R2<20°). Moreover, we calculated the principle component of shank angular velocity (PCAV). MSE values of PCAV signal were calculated on scale (τ) 3 to 8 to form a 6 dimensional feature vector at each trial. The two groups were compared on different MSE scales by one way ANOVA ($p < 0.05$). To minimize redundancy and noise, the feature space dimension was reduced to 2 using principle component analysis. Finally, we used quadratic discriminant analysis (QDA) [4] to show that the two groups are separable using MSE based features.

RESULTS

Fig.1 shows the average MSE±SD calculated in different scales. MSE value at τ = 5,6,8 shows a significant difference between the two groups. Based on QDA algorithm a boundary was found to separate the two groups.

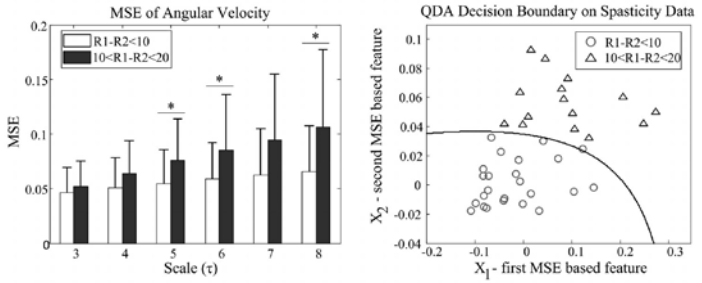


Figure 1. *Left* : MSE of shank angular velocity in different scales. * indicates significant difference between groups. *Right*: QDA decision boundary to separate the two groups using MSE based features

DISCUSSION & CONCLUSIONS

We used MSE as an objective measure for fluctuations of shank angular velocity (due to different levels of pathology). Entropy dissimilarities in different scales between the two studied groups in Fig.1, suggests MSE as a metric to discriminate the patients. The accurate separation of the two groups using QDA pinpoints MSE as a reliable metric. Our method just uses a single 3D gyroscope on the shank to extract features with high discriminative power. Besides, the method is not sensitive to the placement of the sensor which makes it practical candidate for clinical applications.

REFERENCES

[1] Costa M. et al, *Phys Rev E* 2005;71:021906-1-18. **[2]** van den Noort J.C. et al, *Gait Posture* 2009; 30:138-143. **[3]** Gracies J.M., *Arch Phys Med Rehab* 2010; 91: 421-428. **[4]** Velilla S., *Stat Probabil Lett* 2012; 82:739-747.

COMPARISON BETWEEN DIFFERENT ON- AND OFFSET DETECTION METHODS FOR MUSCLE ACTIVITY DURING GAIT FOR CHILDREN WITH CEREBRAL PALSY AND TYPICAL DEVELOPING CHILDREN

Kaat Desloovere[1, 2], Hans Wambacq[3], Annelies Bastiaensen[2], Patricia Van de Walle[1, 2], Lynn Bar-on[1, 2], Catherine Huenaerts[2], Anja Van Campenhout[4, 2], Erwin Aertbeliën[3], Guy Molenaers[2, 4]

[1]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[2]University Hospital, CMAL Pellenberg, Leuven, Belgium
[3]KU Leuven, Department of Mechanical Engineering, Leuven, Belgium
[4]KU Leuven, Department of Development and Regeneration, Leuven, Belgium

INTRODUCTION

Timing of muscle activity during walking can help to understand gait deviations in children with cerebral palsy (CP), but may be subjective and time consuming when done visually. Therefore this study investigated the psychometric characteristics of three automatic methods as well as visual detection (VD) to determine on- and offset of muscle activity during walking in children with CP.

PATIENTS/MATERIALS and METHODS

Nine children with spastic CP (aged 11.7year±2.8) and nine age related typically developing (TD) children underwent gait analysis including surface electromyography of gastrocnemius (GAS) and hamstrings (HAM), following SENIAM[1] guidelines. For 6 gait trials per subject the on- and offset of both muscles was visually defined by two assessors as well as automatically detected by three methods (Staude[2], 2 and 3 standard deviations (SD) threshold) using custom made software(matlab). Correlations (Pearson or Spearman) and differences (one way ANOVA) of activity phases (for stance and swing phase) were calculated between assessors to check on agreement and between visual and automatic methods to verify which of the automatic methods agreed most with VD. Sensitivity of the methods was investigated by comparing TD and children with CP (Mann Whitney U, $p<0.05$). The data analyses were first performed handling each trial as a separate observation (all trial analysis) ignoring the within subject dependency, and secondly on the median data points per patient (median analysis) to verify the impact of within patient variability on the interpretation.

RESULTS

Overall high correlations between assessors were found for both, the GAS and HAM for stance phase, in CP (0.94 and 0.66) as well as TD (0.88 and 0.83), while slightly weaker correlations were found for swing, especially for TD. The correlations between VD and Staude[2] were good to high for GAS and HAM in children with CP (r=0.6-0.9), but lower (0.40-0.60) for TD. The correlations of 'all trial' analyses were always lower than the correlations of the median analyses. The correlations between the threshold methods on one hand and VD or Staude[2] on the other hand were lower (<0.50). We also found significant differences between these methods ($p<0.05$). VD and Staude[2] both showed significant differences between CP and TD, indicating more EMG activity in CP ($p<0.006$), while both threshold methods could not discriminate between CP and TD.

DISCUSSION & CONCLUSIONS

There was high agreement between the two assessors as well as between VD and Staude[2]. However, VD did not correlate with 2SD and 3SD method. Both VD and Staude[2] could differentiate between children with CP and TD, while SD methods could not. All methods were more sensitive to detect stance phase than swing phase activity. Staude[2] method seems to be the most promising automatic detection method but has some limitations that need to be further addressed. The result also highlighted the high variability of EMG signals in pediatric gait. Future automatic algorithms for determining the on-/offset of muscle activity should attack these limitations and within subject variability.

REFERENCES

[1]Hermens et al., Electromyogr Kinesiol 2000, 10:361-74; [2]Staude & Wolf, Med Eng Phys 1999, 21: 449-67.

PROBABILISTIC ONSET DETECTION BASED ON MULTIPLE STRIDES

Hans Wambacq[1], Kaat Desloovere[2], Lynn Bar-On[2], Erwin Aertbeliën[1] and Herman Bruyninckx[1]

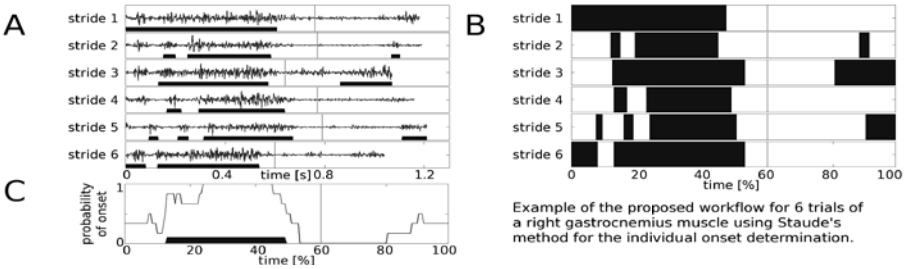
[1]KU Leuven, Department of mechanical engineering, Heverlee, Belgium
[2]University hospital Pellenberg, Laboratory for clinical motion analysis, Pellenberg, Belgium

INTRODUCTION

Due to the high variability of muscle activity collected using surface electromyography (sEMG) during gait analysis, most automatic algorithms for determining muscle on-/offset based on these signals can be tuned to perform well for a single trial, but will then fail for others using the same settings. This is caused by a fundamental issue: most algorithms only use information of a single stride, which is subject to a high variability [1]. The aim of our study was to improve the usability of automatic sEMG onset detection using a probabilistic representation of muscle activation.

PATIENTS/MATERIALS and METHODS

Instead of a binary on-/off representation on a stride-by-stride basis, the concept *probability of onset* is introduced. This probability was computed in three steps: (1) determining the muscle activation stride-by-stride using two algorithms: threshold method [2] and Staudes method [3] (Fig. A, using Staude's method); and time-warping these signals to align the toe-off event for all strides (Fig. B); as well as determining the probability of onset by counting across all strides (Fig. C). The conventional and the proposed methods were compared to the golden standard of manual determination by multiple experts. As performance figure, the number of correct classified points was used. Firstly, this was calculated on a stride-by-stride base comparing the outcome of both methods with our golden standard. Secondly, a calculation on the averaged signals on a muscle-by-muscle base was made after a threshold for onset was put at 0.5. These results were also compared to the experts opinions on a stride-by-stride base.



Example of the proposed workflow for 6 trials of a right gastrocnemius muscle using Staude's method for the individual onset determination.

RESULTS

This methodology showed a slight increase of performance between the averaged signals and the stride-by-stride approach: from 67,76% correct classifications to 69,90% for Staude's method and from 48,75% to 51,35% for the Threshold method.

DISCUSSION & CONCLUSIONS

Although only a minor increase in performance was found, the real strength of this method is the probabilistic outcome. Instead of a binary representation, muscle activity is represented in a probabilistic way, resulting in higher robustness in case of sporadically occurring artifacts. Also the information of several strides is compressed into one single result, resulting in a better overview for clinical reasoning.

REFERENCES

[1] EMG profiles during normal human walking: stride-to-stride and inter-subject variability, D. A. Winter, 1987, [2] Reliability of computerized surface electromyography for determining the onset of muscle activity, R. P. Di Fabio, 1987, [3] Objective motor response onset detection in surface myoelectric signals, G. Staude, 1999

INCREASED FEMORAL ANTEVERSION IS NOT ASSOCIATED WITH INTERNAL HIP ROTATION GAIT IN CEREBRAL PALSY

Reinald Brunner[1], Stefan Thomas[1], Alexej Barg[2] and Erich Rutz[1]

[1]University Children's Hospital Basle UKBB, Pediatric Orthopedic Department, Basle, Switzerland
[2]University Hospital Basle USB, Orthopedic Department, Basle, Switzerland

INTRODUCTION

It is a common doctrine that increased femoral anteversion (FAV) is one of the most important factors for internal rotation gait (IRG) in cerebral palsy (CP). Femoral derotation osteotomy (FDO), proximal or distal, is the current standard treatment for IRG. Several outcome studies, however, report a recurrence rate of IRG up to 33% after FDO [1]. The aim of this study was to investigate if there is a correlation between increased FAV and the mean hip internal rotation in stance phase during gait in CP.

PATIENTS/MATERIALS and METHODS

Retrospective cohort study: 74 legs of 37 patients with CP (n = 33, 18 with spastic diplegia and 15 with quadriplegia) or other neurological disorders (n = 4) (GMFCS level: 6x I, 19x II, 12x III) were included in this study. There were 24 boys and 13 girls with a mean age of 14.1 ± 3.2 years (range: 7-22 y). All participants were scheduled for multilevel orthopedic surgery and had a preoperative 3D gait analysis (3-DGA) including a thorough clinical assessment. cFAV, external tibial torsion (cTT), maximal hip internal (cIR) and external rotation (cER) in extension were measured clinically. The real FAV (rFAV) angle was calculated from standardised anteroposterior pelvic radiographs and the Dunn projection. Foot progression (FP), foot rotation (FR), and hip internal rotation (HR) angles were determinated by 3-DGA (only values during stance phase were analysed). For statistical analysis first a Shapiro-Wilk normality test was performed to verify that the data met the assumptions of a parametric test. The Pearson and Spearman rho correlation coefficient was calculated to analyse the correlations between normally and not-normally distributed data, respectively. The level of significance for all tests was set at $p \leq 0.05$.

RESULTS

rFAV was 37.1 ± 12.2°. Clinical (c)FAV was 26.1 ± 5.9° and cTT was 20.6 ± 10.3°. Hip IR was 53.2 ± 10.2° and hip ER 32.6 ± 13.6°. Middle value of hip rotation (cMV) was 10.3 ± 8.9° towards internal. The results from 3-DGA presented a FP angle of 6.5 ± 19.8°, a FR angle of 7.8 ± 16.8°, and a HR angle of 12.8 ± 16.7°. There was a positive correlation between rFAV and cIR ($r = 0.32$, $p = 0.005$) and negative correlation between rFAV and cTT ($r = -0.27$, $p = 0.02$) and FR ($r = -0.23$, $p = 0.05$). cFAV correlated positively with cIR and cMV ($r = 0.27$ and 0.28, $p = 0.02$ and 0.02). cTT correlated negatively with FP and HR ($r = -0.38$ and -0.21, $p = 0.001$ and 0.08). FP correlated positively with FR and HR ($r = 0.48$ and 0.41, $p = 0.001$ and 0.001), but there was no correlation between rFAV and HR ($r = 0.02$, $p = 0.85$), and no correlation between rFAV and cFAV ($r = 0.07$, $p = 0.55$).

DISCUSSION & CONCLUSIONS

Our results do not support the common doctrine that real FAV is the most important factor that contributes to internal hip rotation in cerebral palsy. We could clearly demonstrate that internal hip rotation gait in cerebral palsy does not correlate with real femoral anteversion determined radiologically. The latter correlates only with maximal hip internal rotation during clinical examination with extended hips. Distally, external tibial torsion in contrast correlates negatively with internal hip rotation and foot progression from 3-DGA. Therefore other factors such as indirect effects resulting from spastic equinus [2] have to be considered as a cause of hip internal rotation during gait.

REFERENCES

[1] de Morais Filho et al., *Gait Posture 2012;Mar 14 (Epub ahead of print)*

[2] Brunner et al., Gait Posture 2008;28-1:150-6

THURSDAY

FRIDAY

P01

COMPARISON OF TWO METHODS FOR DATA ANALYSIS OF OXYGEN UPTAKE IN TYPICAL PAEDIATRIC GAIT

Patricia Van de Walle[1, 2, 3], Rik Gosselink[3], Wambacq Hans[4], Jolien Van Brempt[1], Barbara Callewaert[2], Catherine Huenaerts[2], Kaat Desloovere[2, 3]

[1]Artesis University College, Health Care, Antwerp, Belgium
[2]University Hospital Pellenberg, C-MAL, Pellenberg, Belgium
[3]KULeuven, Rehabilitation Sciences, Leuven, Belgium
[4]KULeuven, Department of mechanical engineering, Leuven, Belgium

INTRODUCTION

Oxygen cost ($ml.kg^{-1}.m^{-1}$) is widespread to measure overall gait efficiency. Oxygen uptake ($ml.kg^{-1}.min^{-1}$) during walking can be easily measured by light weight breath by breath equipment. During a submaximal steady state exercise the uptake of oxygen mirrors the energy expenditure. It is therefore important to assure that steady state is reached before data are analyzed. The most conventional method is to average all breaths during a certain period. Recently more objective statistical and mathematical methods omitting non steady breaths were proposed and it was suggested that they could minimize measurement error and thus decrease variability [1,2]. It is not yet clear if these new methods indeed provide different outcome results and are superior to the conventional ones.

PATIENTS/MATERIALS and METHODS

Ninety-one children with typical development (5-18 years) were selected from an existing reference data set. Oxygen uptake was measured breath by breath with K4b2 (Cosmed, Rome, Italy) at rest (5 min) and during walking (8 min) after ≥3 hours of food deprivation. Data were analyzed (1) conventional, averaging all breaths during the last 2 min at rest and min 3-6 of walking, leaving out the first 3 min to assure steady state, and (2) by the method proposed by Schwartz [1] that only selects breaths without rising or falling trend based on Kendall's tau statistics (KT-method). It thus omits non steady breaths and computes mean oxygen uptake of all steady breaths. Oxygen uptake was compared for both methods (paired sample t-test; $p \leq 0.05$). The relation between the methods was investigated with Pearson correlation coefficient.

RESULTS

No significant differences were found between the two methods for oxygen uptake at rest or during walking (p=0.22-0.67). Correlation between both methods was high with r=0.75 for oxygen uptake at rest and r=0.96 for oxygen uptake during walking. Variation was higher for oxygen uptake at rest (34-39%) compared to oxygen uptake during walking (24-25%) but similar for both methods.

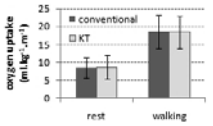


Figure 1: Oxygen uptake at rest and during walking with two methods of data analysis.

DISCUSSION & CONCLUSIONS

As no differences were found between the conventional and the KT-method for oxygen uptake at rest or during walking, we conclude that the choice of analysis method does not influence outcome nor variability. Both investigated methods can therefore be used interchangeable. It seems that data analysis method is not responsible for high inter subject variability at rest in typical children.

REFERENCES

[1] Schwartz Gait Posture 2007; 26(4), p 494-500; [2] Plasschaert Gait Posture 2010; 31, p537-53

P03

INFLUENCE OF ANTHROPOMETRIC VARIABLES IN PEDIATRIC GAIT PARAMETERS

David Gómez-Andrés[1], Irene Pulido-Valdeolivas[1], Juan Andrés Martín[2], Javier López[3] and Estrella Rausell[1]

[1]Trastornos del Desarrollo y Maduración Neurológica. IdiPaz. Universidad Autónoma de Madrid.
[2]E.U. Fisioterapia ONCE-UAM. Universidad Autónoma de Madrid.
[3]Hospital Universitario Infanta Sofía, S.S. de los Reyes (Madrid)

INTRODUCTION

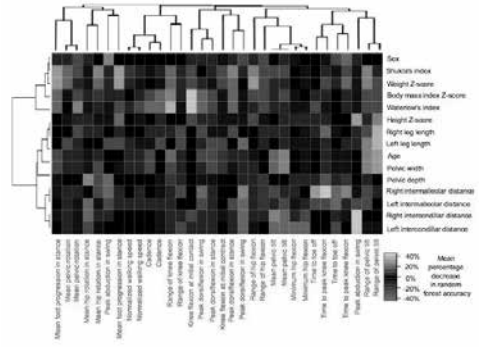
Gait is a complex output of interaction among central nervous system, musculoskeletal apparatus and environment. Although growth is a key element on gait maturation, few studies have analysed how anthropometric variations are related with children gait pattern.

PATIENTS/MATERIALS and METHODS

A carefully studied dataset of 27 healthy school-aged children was selected. The 16 left and the 16 right kinematic parameters used to calculate Gillette Gait Index were measured in each child and a mean of 4-5 cycles was obtained for each parameter. Random forests were trained by using each gait parameter as independent variable and age, sex, Z-score for age and sex of height, weight and BMI, Waterlow's and Shukla's indexes, pelvic width and depth and leg length, intercondillar and intermaleollar distance of each side. Goodness of fit of each one was estimated by pseudo-R^2 and the influence of each dependent variable in each model was estimated by mean percentage of decrease in model accuracy when variable is out of the bag.

RESULTS

Performance of our predictive models was modest, but significant relationships among anthropometric variables and gait parameters were found. The following figure is a heatmap. In each interaction, it shows the importance calculated for each anthropometric variable in the estimation of a particular gait parameter (left parameters in green, right, in red). Hierarchical clustering analysis reorder anthropometric variables and gait parameters. The greener the square, the most important is the particular variable in estimation of the particular gait parameters. Notice how different clusters of anthropometric variables are related with different gait parameters.



DISCUSSION & CONCLUSIONS

The relationship among some gait parameters and some anthropometric variables has two main consequences. First, a personalization of normal gait target for each patient should be defined in clinical studies. Second, growth and differential growth of body parts should be assessed in longitudinal studies involving both normal and disabled children

REFERENCES

[1] Liaw A et al. Classification and regression by random Forest. R News 2003; 2/3. [2] Pulido-Valdeolivas I et al. Parámetros de marcha en una muestra de referencia de escolares sanos españoles. Neurologia 2012; accepted.

NEW INSIGHTS INTO MUSCLE WORK ESTIMATION DURING GAIT

Davide Conte[1], Nicola Petrone[2], Alessandro Ceccato[3], Diego Pigatto[3], Cristina Smiderle[3] and Carlo Capelli[1]

[1]University of Verona, Dep. of Neurological, Neuropsychological, Morphological and Movement sciences, Verona, Italy
[2]University of Padova, Dep. of Mechanical Engineering, Padova, Italy
[3]Azienda Sanitaria ULSS 3, Dep. of Physical Medicine and Rehabilitation, Bassano del Grappa, Italy

INTRODUCTION

The estimation of muscle mechanical work (MMW) can be useful to assess movement efficiency. Different methods to estimate MMW during walking have been presented in the literature: the *external+internal work* [1], the *segmental work* [2] and the *joint work* [3] models. Although attempts have been made to investigate differences among them [3, 4], all methods are still used in research and clinical applications. However, each method was originally based on different assumptions about i) between segments energy transfers, ii) interpretation of negative muscle work, iii) different meaning given to common terms as *internal* work. A deeper understanding of theoretical differences and analogies would allow to know what is exactly computed by each method and help to make a more appropriate use of this information.

PATIENTS/MATERIALS and METHODS

Kinematic and kinetic data from 10 healthy children (age 9.8±2.7 y, height 1.36±0.17 m, weight 33.9±11 Kg) walking at self-selected speed were acquired with an 8 cameras Vicon system and 2 force plates (AMTI, Kistler). Three gait cycles were selected for each subject. A 16 segments full-body 3D model was validated and used to compute pi(t) functions as *joint* powers, or e*xternal* (associated to the centre of mass, COM) + *internal* (associated to the segments movement relative to the COM) powers, or *segmental* powers, during the gait cycle. Inertia parameters were scaled for children. For each method, different whole-body power curves, P(t), were obtained by summation of the pi(t) functions depending on the energy transfers allowed between segments (i.e. introducing or not absolute values among power terms to be summed). The same conditions were applied to all methods. By integrating P(t) curves, different values for MMW were obtained: W+, W-: total positive/ negative work allowing no energy transfers; Wnet: (W+) + (W-); |W|: |W+| + |W-|; Wabsnet: integration of |P(t)|, allowing all possible energy transfers between segments, but no energy recuperation during time. External work was computed from COM kinematics and via *individual limbs* method [5]. W+ and Wabsnet values were compared between methods through one-way ANOVA with posthoc Bonferroni correction.

RESULTS

Analysis demonstrated that all methods are equivalent when energy transfers between segments are allowed (Wabsnet). With no transfers, *joint* and *segmental* methods give equivalent results, both differing significantly from work values computed via the *external+ internal* method. The difference is reduced, but still significant, with *external* work computed via the individual limbs method. Wnet values are almost zero, as expected from walking at constant speed, and |W| is therefore close to 2*W+.

DISCUSSION & CONCLUSIONS

Allowing for all possible energy transfers, all methods are equivalent. Significant differences appear when transfers are prevented, ignoring negative work, W+, or adding it as absolute value, |W|. However, all the computed quantities rely on artificial hypothesis and is therefore important to be aware of which method is being used and which conditions have been defined regarding energy transfers. Also, different results may be obtained with movements different from level walking.

REFERENCES

[1] Cavagna and Kaneko, J.Physiol, 1977. [2] Winter, J.Appl.Physiol, 1979. [3] Aleshinsky, J.Biomech, 1986.
[4] Van de Walle et al, Gait Posture, 2012. [5] Donelan et al, J.Biomech, 2002

SPATIO-TEMPORAL PARAMETERS OF TURNING IN HEALTHY CHILDREN

Philippe C Dixon[1], Amy B Zavatsky[1], Julie Stebbins[2] and Tim Theologis[2]

[1]University of Oxford, Dept of Engineering Science, Oxford, United Kingdom
[2]Oxford University Hospitals NHS Trust, Nuffield Orthopaedic Centre, Oxford, United Kingdom

INTRODUCTION

Turning while walking is a crucial part of locomotion, however little is known about the biomechanics of turning maneuvers. The aim of this study was to identify the adaptations required for healthy children to navigate turns.

PATIENTS/MATERIALS and METHODS

Thirty-one healthy children performed barefoot walking in a straight line and 90° turns at self-selected veolcity. Seventeen children (12 girls, 12.6 ± 2.3 years, height 1.6 ± 0.1 m, and leg length 0.8 ± 0.1 m) independently chose to perform turning with both the inside (spin) and outside (step) foot, and were retained for statistical analysis. Three turning phases were analyzed (approach, turn, and depart strides) while left and right trials were pooled. Retroreflective markers were used to automatically detect foot strike and foot off events [1] required to compute spatio-temporal data [2]. Spatial data were normalized to leg length while absolute temporal variables were reported [3]. One-way repeated measures ANOVA with Bonferroni correction were performed on stride velocity, stance time, stride length, and stride width.

RESULTS

Half of all children turned utilizing only the spin strategy while no child solely attempted step turns. Statistical analysis revealed that both turning conditions were different from straight walking. The main differences occurred between turning phases for step and spin conditions while only a few differences were found between turning types (Table 1).

Table 1: Spatio-temporal parameters for healthy children during straight and turning conditions (n=17)

	Stride velocity(m/s)	Stance Time (s)	Stride length	Stride Width
Straight	1.31 [1.22 , 1.40]	0.59 [0.55 , 0.62]	1.56 [1.50 , 1.63]	0.10 [0.09 , 0.11]
Spin Approach	1.16 [1.08 , 1.24]*	0.60 [0.57 , 0.64]	1.41 [1.35 , 1.48]*	0.19 [0.16 , 0.21]*
Spin Turn	1.00 [0.93 , 1.08]*^{a}	0.65 [0.61 , 0.69]*^{a}	1.37 [1.32 , 1.42]*	0.14 [0.12 , 0.17]
Spin Depart	1.00 [0.94 , 1.06]*^{a}	0.61 [0.57 , 0.65]^{t}	1.32 [1.26 , 1.39]*	0.28 [0.25 , 0.31]*^{a}
Step Approach	1.17 [1.08 , 1.26]*	0.61 [0.57 , 0.66]	1.46 [1.38 , 1.53]*	0.07 [0.04 , 0.09] ^{s}
Step Turn	0.99 [0.92 , 1.07]*^{a}	0.63 [0.59 , 0.68]*	1.18 [1.12 ,1.25]*^{sa}	0.36 [0.34 , 0.39]*^{sa}
Step Depart	0.93 [0.87 , 1.00]*^{sa}	0.64 [0.60 , 0.67]*	1.38 [1.33 , 1.44]*^{t}	0.07 [0.04 , 0.10]st

Mean [95% confidence interval]. Superscripts indicate statistical difference from straight (*), approach stride same condition (a), turn stride same condition (t), and between conditions for the same phase (s).

DISCUSSION & CONCLUSIONS

The present cohort preferred turning using an inside foot strategy regardless of an increased risk of fall and increased muscular demand previously reported [4] and decreased stride width found here. However, it remains unclear how other populations, such as children with cerebral palsy, would perform turning maneuvers. Investigation of turning may provide greater insight into the biomechanical adaptations required for independent ambulation and may lead to the development of more functional rehabilitative programs and improved surgical outcomes.

REFERENCES

[1] Zeni, J.A., et al. (2008). Gait Posture **27**(4); [2] Huxham, F., et al. (2006). Gait Posture. 23(2) **;** [3] Hof, A.L. (1996). Gait & Posture. 4 ; [4] Taylor, M.J., et al. (2005). Hum Mov Sci. 24(4)

CLINICAL AND INSTRUMENTAL EVALUATION OF BOTULINUM TOXIN EFFECTS ON THE "IDIOPATHIC TOE WALKING": A PILOT STUDY

Maria Grazia Benedetti[1], Isabella Fusaro[1], Silvia Volini[1], Giuseppe Gasparre[1] and Lisa Berti[2]

[1]Istituto Ortopedico Rizzoli, Physical Medicine and Rehabilitation Unit, Bologna, Italy
[2]Istituto Ortopedico Rizzoli, Movement Analysis Laboratory, Bologna, Italy

INTRODUCTION

"Toe-walking" is an idiopathic condition observed in childhood, characterized by the persistence of walking on the tips; the pathogenesis is not completely known and the diagnosis can be made only after excluding other nerve or muscle disorders[1]. The existing literature on its treatment with Botulinum toxin is poor, and there is agreement on the need to identify an effective therapy to avoid long-term consequences such as back pain related to the pelvic anteversion, and the development of a structured equinus[2]. The purpose of this study was to evaluate the effectiveness of the treatment with Botulinum Toxin A of calf muscles in children with Idiopathic Toe Walking.

PATIENTS/MATERIALS and METHODS

Nine children with a mean age of 7.6 years were included in this pilot study. Neurological origin of the equinus was clinically excluded. Silfverskiold Test, popliteal angle, and instrumental evaluation performed with Vicon Motion System for joint kinematics were used as outcome measures. Each child was injected with Botulinum Toxin A, dosage relative to body weight (6 U / kg) in gastro muscle bilaterally. The treatment was supplemented with the use of an AFO and with a program of stretching exercises. The follow-up assessment was carried out at 1 and 3 months post injection. Data were statistically analyzed with the GLM method with values pre-post treatment as fixed effect and patient as random effect, accepting a significance of $p < 0.05$.

RESULTS

Results followed up to three months showed a significant improvement in gait pattern, both clinically (mean dorsiflexion pretreatment 0 ° post treatment 5 °) and instrumentally (Table 1). Statistical analysis did not find significant changes at the ankle kinematics although differences in the kinematic pattern in the three planes of the space is evident from graph in dorsiflexion peak timing during stance (Fig. 1)

Table 1	*PRE- treat*		*POST-treat 1 month*		*GLM analysis*	*POST-treat 3 month*		*GLM analysis*
	Mean	SD	Mean	SD	p	Mean	SD	p
Speed (cm/s)	113,3	19,7	101,8	18,3	0,03	109,6	19,6	ns
Pelvis Max Rot sag plane (deg)	16.7	5,2	16,2	3,6	ns	11,4	3,3	<0.0005
Hip L Max int rot stance (deg)	7,1	7,0	2,4	7,6	0,02	4,5	10,3	0,03
Hip R Max int rot stance (deg)	6,7	7,4	2,1	9,4	0,05	4,0	5,6	0,04

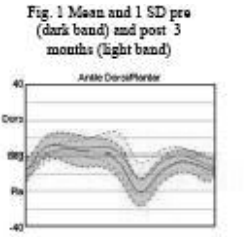


Fig. 1 Mean and 1 SD pre (dark band) and post 3 months (light band)

DISCUSSION & CONCLUSIONS

Although this study is limited by a small number of patients and the lack a control group, preliminary results on a very well selected and documented sample of children are encouraging on the positive effects of Botulinum Toxin on ankle-foot kinematics during stance and on compensative anteversion in the pelvis. Improvement is evident at three months post injection. It is reasonable to interpret this time as necessary for musculo-skeletal reorganization. This pilot study will be used to design a RCT with a control group treated with a standard program of exercise and AFO.

REFERENCES

1. Hirsch G, et al. Acta paediatr. 2004 Feb; 93(2):196-9. 2. Caselli MA, et al. Clin Podiatr Med Surg. 1988 Jul;5(3):547-59.

DEVELOPMENT OF BALANCE IN OVERWEIGHT AND OBESE CHILDREN FROM 7 TO 14-YEARS-OLD

ANA C DE DAVID[1] and MARCELLA M BARBACENA[1]

[1]UNIVERSITY OF BRASILIA, PHYSICAL EDUCATION FACULTY, BRASILIA, BRAZIL

INTRODUCTION

In addition to the metabolic and cardiac diseases, already well documented, the obesity affects the musculoskeletal development and may have long-term implications during adulthood. Gait analysis in obese children has showed differences in double support, stance, and swing phases of the gait cycle and diminished dynamic stability when compared to healthy children [1]. However, it is not clear how overweight and obesity affect the postural balance during childhood and early adolescence. Increased instability and major dependency on vision system have been reported [2,3]. On the other hand, some investigations have found no differences between normal-weight and obese children balance during the quiet standing posture. Therefore, the purpose of this study was to verify the association between postural balance and age from 7 to 14 years-old in obese, overweight and normal weight children.

PATIENTS/MATERIALS and METHODS

The postural balance of 438 subjects (201 normal weight, 136 overweight and 101 obese) using Cole et al [4] was assessed. They were divided into four age groups (7-8, 9-10, 11-12 and 13-14). An AMTI AccuSway Plus force plate at a frequency of 100Hz was used to measure the anterior-posterior amplitude (COPap), medio-lateral amplitude (COPml), mean velocity (COPvel) and 95% area of the ellipse (COParea) for three trials (30 s) standing in comfortable feet apart and eyes open. Pearson correlation coefficient and ANOVA (Tukey post-hoc test) were used to statistical analysis.

RESULTS

Obese group had significant ($p<0.01$) greater sway for 13-14 years-old than normal weight and overweight groups only for COParea. There is no other significant difference between groups. Moderate correlations are found between age and balance variables for normal weight and overweight groups as shown in Table 1 while obese group had poorest correlation with no-significant values for COParea, COPml and COPap. COPvel showed stronger correlation with age than the other measures for all groups.

Table 1: Pearson´s coefficient correlation values between age and COP variables.

		COP_Vel	COP_Area	COP_ML	COP_AP
Normal-weight	(n=201)	-.40*	-.39*	-.41*	-.26*
Overweight	(n=136)	-.51*	-.42*	-.47*	-.34*
Obese	(n=101)	-.37*	-.12	-.18	-.06

* Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION & CONCLUSIONS

As to be expected, balance becomes better as age increases. Similar with others studies postural balance was measured during quiet double leg stance using natural base of support. This less challenging foot position might explain the absence of BMI group differences. Significantly lower motor coordination in overweight and obese children when compared to normal-weight children on more dynamic situations reported in some studies support this idea. According our results balance improves from 7 to 14-years-old in a similar way in normal weight, overweight and obese children for quiet standing double leg posture. It seems related more with age than with weight status.

REFERENCES

1.McGraw, B. et al. *Arch Phys Med Rehabi* . **81**. 484-489. 2000.

2.Hue O. et al. *Gait Posture.* **26**. 32-38. 2007.

3.D´Hont E. et al. *Gait Posture.* **33**. 179-184. 2011.

4. Cole TJ et al. *British Med J.* **320**. 1-6. 2000.

KINEMATICS OF THE GAIT OF CHILDREN WITH PES VALGO-PLANUS AND GENU VALGUM

Elzbieta Pretkiewicz-Abacjew[1]

[1]Gdansk University of Physical Education and Sport, Gdansk, Poland

INTRODUCTION

The incorrect functional structure of the feet and knees in children during the period of growth has a detrimental effect on the performance of movement in joints of the whole leg, of the spine and on the body posture [1]. The aim of the study was investigating the most important characteristics of the gait of six-year-old children with *pes valgo-planus* and *genu valgum* and comparing these with the results obtained for the gait of children who conformed to the structural norms.

PATIENTS/MATERIALS and METHODS

An examination was carried out of six-year-olds of both sexes, from whom an experimental group was formed of 36 children with *pes valgo-planus* and *genu valgum* (VP & GV) and a control group was formed of 33 children with conformed to the structural leg norms applying the methods of gait examination described below (N). The assessment of the arch of the foot was based on plantography and podoscopy methods, upon which the degree of the flatness of the longitudinal arch of the right and left arch of the foot was obtained. The degree of the valgus deviation of the calcaneal bone axis from the vertical measured by a goniometer exceeding 6.0° was taken to denote *tarsus valgum.* A distance between the medial malleola during standing exceeding 6.0 cm was taken as denoting knock knee (GV). The children's gait was recorded at a frequency of 50 Hz [2]. A commercially produced computer program was used for processing and recording the data obtained. The stride period, the double and single support phases and the length of the swing phase were analysed. Stride length over the whole cycle, gait velocity and cadence were calculated. Step width was examined (in relation to the distance between the hip joints and the length of the lower limb) and the angular values were obtained for the positioning of the tibial bone in relation to the tarsus and for the position of the thigh and tibia in the knee joint.

RESULTS

Statistically significant differences between the children with VP &GV and N children emerged in all the kinematic features of gait analysed. In children with VP & GV stride length and its relation to the distance of the hip joint were found to be smaller, as were swing phase, average values for gait velocity and cadence. The average values for stride period, single and double support were greater. Analysis of gait revealed similar angle values for each limb. The children with VP & GV had a greater angle of deviation of the axis of the calcaneal bone from the vertical than the N children and a greater angle between the longitudinal foot axis and the line of progression. In children with VP & GV the valgus positioning of the tibia and the thigh in the knee joint deteriorated significantly during gait, while in N children the positioning was slightly varus. The positioning of the feet wide apart in gait in children with VP & GV exceeded the average distance between the hip joint (135.7 %).

DISCUSSION & CONCLUSIONS

The children with VP & GV were similar to the N children only in height. The children with VP & GV had a greater body weight, confirming the view that one of the reasons for VP & GV is increased body mass. The results of the gait examination of the Gdansk N children are similar to those obtained by other authors, such as Sutherland et al [3], for children of the same age. In comparison with the N children, gait assessment for children with VP & GV, revealed the need for prophylaxis and correction.

REFERENCES

[1] Gage J.R. (Edit.) The Treatment of Gait Problems in Cerebral Palsy. Mac Keith Press, 2004.

[2] Pretkiewicz-Abacjew E., Journal Sports Medicine and Physical Fitness, 2003.

[3] Sutherland D.H. et al. The Development of Mature Walking. Mac Keith Press, Oxford, 1988.

PMW – PREVENTIVE MOBILITY WORKOUT – EFFECTS OF A STANDARDIZED TRAINING ON PATIENTS WITH JUVENILE IDIOPATHIC ARTHRITIS (JIA)

Florian Kreuzpointner[1], Matthias Hartmann[2], Marianne Spamer[2], Mathias Georgi[2], Silvia Schroedl[2], Renate Haefner[2], Johannes-Peter Haas[2] and Ansgar Schwirtz[1]

[1]Technische Universität München, Department of Biomechanics in Sports, Munich, Germany
[2]German Center for Pediatric and Adolescent Rheumatology, Garmisch-Partenkirchen, Germany

INTRODUCTION

Sport & rheumatism and especially sport in juvenile idiopathic arthritis (JIA) is a red-hot topic within rheumatology. Several studies show that patients with JIA has deficits in some motor skills (as Singh-Grewal et al. 2007). Therefore we analyzed results from motion analysis studies to get a precise idea where limitations are. JIA patients´ gait with less range of motion resembles a crouch-like gait. The JIA patients have increased pelvic tilt, increased hip flexion, increased knee flexion and more ankle flexion (Hartmann et al. 2010) or suffer from muscular weakness within the plantar flexors (Brostrom et al. 2004). So we developed a special training, the preventive mobility workout (PMW), to counteract those deficits.The purpose of this pilot study was whether the training shows effects during an inpatient health care.

PATIENTS/MATERIALS and METHODS

8 JIA patients (w=6, m=2, age=14.9±3.4a) were included in this pilot study so far. Four patients suffer from ext. Oligoarthritis, two from polyarthritis, and two from psoriasis arthritis. The control group includes n=3 (w=3, age=14±2) so far. Both had to accomplish the PMW daily for 10 days. It consists of 6 exercises which tend to strengthen the plantar flexors and knee extensors, stretches the hip flexors and plantar flexors and stabilize the core and the ankle. The training lasts 10 minutes and is designed for integration in the patients´ daily routine. The patients performed the training additionally to their every day physiotherapy. Stability was measured with the S3-check balance board (proxomed, Swiss). The path of the COP was calculated while performing the Matthiass test (core stability) for 30s on an emed x platform (Novel, Germany). Flexibility was measured using the FFD (finger floor distance). For statistical analysis an ANOVA was calculated and a student´s t-test to compare effects over time.

RESULTS

Parts of the results are presented as follows. We found no interaction effects between both groups. Patients showed a statistically significant enhancement in their flexibility ($p<0.05$) after the ten trainings sessions. The core stability and the balance didn´t improve over time, although core stability showed a moderate effect size (Cohen´s D=0.7).

	balance (S3-check) [index]		core stability (COP) [cm]		flexibility (FFD) [cm]	
	Mean (n=7)	SD	Mean (n=8)	SD	Mean (n=8)	SD
t1	4.2	1.2	32.8	13.4	13.8	4.8
t2	4.2	1.5	27.3	7.7	9.7	5.2

DISCUSSION & CONCLUSIONS

Takken et al. (2008) concludes in his review that exercise therapy didn´t show statistically significant effects on functional abilities and therefore claims standardized therapy. PMW is a standardized approach to treat certain deficits in motor abilities of patients with JIA. The results here indicate that PMW shows effects on the JIA patients. The improvement of flexibility and the moderate effect size of the core stability are indicator for further research on this topic. The patients report no detrimental effects due to the intervention. The next steps are to enlarge the sample sizes and to analyze long-term effects.

The authors wish to thank the “Kinder-Rheumastiftung” for funding this study.

REFERENCES

Brostrom, E. (2004).Arch Phys Med Rehabil 85(8):1224-30. Hartmann, M. (2010).Int J Pediatr pii:835984. (Epub 2010 Sep 2.). Singh-Grewal, D. (2007).Arthritis Rheum 57(7):1202-10. Takken, T. (2002).J Rheumatol 29(12):2643-7

PREMATURE ANKLE PLANTARFLEXOR ACTIVITY DURING GAIT: AN EVALUATION OF 647 PATIENTS WITH DIVERSE PATHOLOGIES

Jacqueline Romkes[1], Katrin Schweizer[1] and Reinald Brunner[1]

[1]University Children's Hospital Basel, Laboratory for Movement Analysis, Basel, Switzerland

INTRODUCTION

Premature plantarflexor muscle activity (PPF) during the first 10% of the gait cycle in walking is a common deviation observed in patients with diverse pathologies. Among the aetiological factors are biomechanical alterations and/or muscular weakness [1,2]. The aim of this study was to evaluate if these factors for PPF are independent of the pathology.

PATIENTS/MATERIALS and METHODS

Gait analysis data of 647 patients were investigated retrospectively. Seven pathological groups were defined: orthopaedic uni-/bilateral (OUni/OBi); neurological flaccid uni-/bilateral (NflaUni/NflaBi); neurological spastic uni-/bilateral with/without adequate trunk control (NspUni/NspBi/NspBiNTC). PPF was defined as constant m. gastrocnemius surface EMG activity during 0-10% of gait cycle that exceeded 28%, 23% and 31% of peak activity calculated over the entire gait cycle. The gait profile score (GPS) [3] was calculated as a measure of overall gait deviation. Manual muscle strength (MMS, scale: 0-5 with 5=normal) of the leg muscle groups [4] was tested and averaged across the muscles to detect muscle weakness.

RESULTS

The number of patients with PPF in each group and the subgroups 'normal MMS' (≥4.5), 'reduced MMS' (<4.5), 'normal GPS' (≤7.3°), and 'abnormal GPS' (>7.3°) are shown in figure 1. PPF is more frequent in patients with reduced MMS/abnormal GPS than in patients with normal MMS/GPS, except for the NflaUni group (may be biased by the small group size).

DISCUSSION & CONCLUSIONS

PPF is an abnormality with clinical relevance, as its prevalence is more than 10% in each patient group. Muscle strength and kinematic deviations both seem to be among the aetiological factors, independent of the pathology. Consequently, PPF should rather be regarded as a secondary deviation than a primary abnormality.

REFERENCES

[1] Romkes J and Brunner R. Gait Posture 2007;26:577-86.

[2] Brunner R and Romkes J. Gait Posture 2008;27:399-407.

[3] Baker R et al. Gait Posture 2009; 30: 265-9.

[4] Hislop HJ and Montgomery J. Manuelle Muskeltests;1999.

ACKNOWLEDGEMENT

Swiss National Science Foundation (SNF): 32003B 127534.

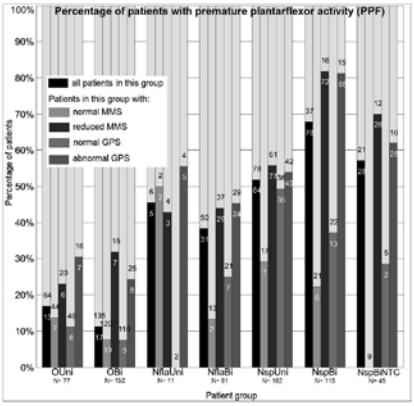


Figure 1. The figure shows the number of patients with premature plantarflexor activity (PPF) for the seven pathological groups: OUni/OBi: orthopaedic uni-/bilateral; NflaUni/NflaBi: neurological flaccid uni-/bilateral; NspUni/NspBi/NspBiNTC: neurological spastic uni-/bilateral with/without adequate trunk control.

3D GAIT ASSESSMENT IN CHILDREN WITH CEREBRAL PALSY USING FOOT-WORN INERTIAL SENSORS

Christopher J Newman[1], Benoit Mariani[2], Aline Brégou Bourgeois[3], Pierre-Yves Zambelli[3] and Kamiar Aminian[2]

[1]Lausanne University Hospital, Pediatric Neurology and Neurorehabilitation Unit, Lausanne, Switzerland
[2]Ecole Polytechnique Fédérale de Lausanne, Laboratory of Movement Analysis and Measurement, Lausanne, Switzerland
[3]Lausanne University Hospital, Pediatric Orthopedics and Traumatology Unit, Lausanne, Switzerland

INTRODUCTION

Generally, spatio-temporal gait analysis requires dedicated laboratories with complex systems such as optical motion capture. It is likely that a child's natural gait pattern may be affected by a short distance walkway and the laboratory setting. Recently, ambulatory devices have overcome some of these limitations by using body-worn sensors measuring and analyzing gait kinematics.

The aim of this study was to explore the use of foot-worn inertial sensors as a 3D gait measurement tool during a 200-meter walking test in independently walking children with cerebral palsy (CP).

PATIENTS/MATERIALS and METHODS

We performed a case-control study. We analysed 14 children with CP, aged 6 to 15 years old, who were followed in our tertiary outpatient child neurorehabilitation Unit and 15 controls. There were no significant differences in age (CP 11.4±3.6 years, controls 10.6±2.6 years) or gender between cases and controls . In the CP group 9 children were graded GMFCS I, 5 were graded GMFCS II, 12 children had unilateral and 2 had bilateral CP.

Two U-shaped and two 8-shaped trial walks per subject were performed during which the accuracy and precision of the foot-worn device was measured using an optical motion capture system (Vicon,Oxford Metrics) as the reference system. All subjects then performed a continuous 200-meter walk test at their self-selected pace wearing the foot-worn inertial sensors (Physilog III, LMAM-EPFL, Switzerland). Limb-related spatio-temporal parameters were compared between paretic and control limbs while bilateral gait characteristics were compared between CP and control subjects, using non-parametric analyses.

RESULTS

Mean accuracy±precision for both groups was 3.4±4.6 cm for stride length, 4.3±4.2 cm/s for stride velocity and 0.5±2.9° for initial contact foot pitch angle.

For temporal parameters paretic limbs showed longer stance (61.9±2.5% vs 60±0.9%, P=0.006) and shorter swing (38.1±2.5% vs 39.9±0.9%, P=0.006) phases, with an increase in double support in children with CP (24.8±4.7% vs 20.3±1.7%, P=0.001). For spatial parameters stride length (1.07±0.18 m vs 1.32±0.14, P<0.001), speed (1.13±0.23 m/s vs 1.39±0.11 m/s, P<0.001) and peak angular velocity during swing (385±74°/s vs 450±41°/s, P<0.001) were decreased in paretic limbs, with significant differences in foot pitch at both heelstrike and toe-off (P<0.001). Both maximal heel clearance (22.7±3.1 cm vs 25.6±3.5 cm, P=0.004) and maximal toe clearance (7.6±2.9cm vs 13.4±1,6cm, P<0.001) were lower in paretic limbs.

DISCUSSION & CONCLUSIONS

Foot-worn inertial sensors allowed us to analyze gait kinematics outside a laboratory environment with a good accuracy and precision. The case control comparison yielded results which were congruent with what is known of gait variations in children with cerebral palsy who walk independently. Participants found the system light weight and easy to wear and use. While not substituting for complete 3D gait analysis, portable sensors provide precise information about gait in conditions that are closer to the child's habitual environment and motor behaviour, and could therefore prove to be a useful complement.

REFERENCES

APPLICABILITY OF USING INERTIAL SENSOR DURING GAIT ANALYSIS FOR HEMIPLEGIA PATIENTS: CASE SERIES

João P Batista Junior[1], Bruno F Mazuquin[1], Karen Obara[1], Ligia M Pereira[1], Marcelo A Costa[1], Rodrigo L Carregaro[2], Paulo RG Lucareli[3], Edson L Lavado[4] and Jefferson R Cardoso[1]

[1]Master/PhD Program in Physical Education and Rehabilitation, UEL-UEM-UNOPAR
[2]UNB, Brasilia, DF, Brazil
[3]UNINOVE, São Paulo, SP, Brazil
[4]Laboratory of Biomechanics and Clinical Epidemiology, Universidade Estadual de Londrina, Londrina, PR, Brazil

INTRODUCTION

Post-stroke patients often present motor alterations and locomotion disturbances due to cerebral damage, which has great impact on functional independence [1]. Gait analysis approaches have been developed for assessing human walking and the use of inertial sensor systems should be considered [2]. Thus, the aim of this study was to describe and to observe the applicability of a gait analysis by using inertial sensor of the two different arteries in stroke patients.

PATIENTS/MATERIALS and METHODS

This study was previously approved by the Ethics Committee of the Universidade Estadual de Londrina (State University of Londrina) (EC # 177/2011). Two patients (A and B) (age: 57 and 63 years, height: 168 and 170 cm, mass: 70 and 76 kg) who had suffered a basilar and middle cerebral artery ischemic stroke (right paresis) respectively, for 6 and 4 years and Barthel Index scores of 100 and 85 (100 represents the highest independence) were included in this study. The MVN (Xsens Tech, Holland) system, with 17 inertial sensors for the whole body was used. The sensors (38x53x21 mm) and the Xbus master communicate with a PC using Bluetooth system. The subjects were familiarised and oriented to walk 3 times on a 6 m walkway at a self-selected pace. The acquisition rate was 120 Hz. Angular data was selected and plotted as a gait cycle percentage in the sagittal plane. The gait cycle difference between maximum and minimum values for both subjects were analysed.

RESULTS

The subject A had peak angles of hip flexion: 28˚, knee flexion: 66˚ and dorsiflexion: 17˚ with the hemiparetic limb. The subject B had peak angle of hip flexion: -7˚, knee flexion: 31˚ and dorsiflexion: 13˚ with the hemiparetic limb.

DISCUSSION & CONCLUSIONS

In this study, post-stroke patients had different gait patterns and the patient A behaved similarly to healthy subjects. For this patient (A) the maximum hip flexion (28º) occurred during the oscillation phase at 80% of the gait cycle. The patient B showed a predominant hip extension compensatory strategy, with limited flexion. A maximum knee flexion value (66º) between the stance and swing phases (50-70% of gait cycle) was observed on patient A while patient B seemed to show a rigid knee flexion during the whole cycle. For the ankle analysis, the patient A presented a maximum flexion angle (17 º) between the terminal stance and toe-off and patient B performed an extension movement at the stance phase and at the midswing. For the patient (B) there was flexion maintenance between midstance and toe-off stance phase, which also suggests that he adopted a compensatory and rigid semiflexion strategy [3]. In conclusion, the use of inertial sensors allowed describing the gait cycle of post-stroke patients. However some disturbances in the magnetic field may have affected the magnetometer output and must be taken into consideration in future studies.

REFERENCES

[1] Pereira LM et al. Electromyographic activity of selected trunk muscles in subjects with and without hemiparesis during therapeutic exercise. J Electromyogr Kinesiol 2011;21:327-32. [2] Guo Y et al. A low-cost body inertial-sensing network for practical gait discrimination of hemiplegia patients. Telemed J and Health 2012 *(in press)*. [3] Wooley SM. Characteristics of gait in hemiplegia. Top Stroke Rehabil 2001;7:1-18. Stroke Rehabil 2001;7:1-18.

CAN A TURNING INWARDS PATELLA PREDICT AN EXCESS OF FEMORAL ANTEVERSION?

Anne L Simon[1], Ana Presedo[1], Brice Ilharreborde[1], Fabrice Megrot[2], Keyvan Mazda[1] and Georges F Penneçot[1]

[1]Robert Debré Hospital, Orthopaedic Surgery, Paris, France
[2]CRF Bois Larris, Croix Rouge, Gait Laboratory, Lamorlaye, France

INTRODUCTION

In children with spastic diplegia, a turning inwards patella during gait is often considered to be related to an excess of femoral anteversion.

The aim of our study was to investigate the relationship of these two parameters during gait.

PATIENTS/MATERIALS and METHODS

We retrospectively reviewed the charts of 188 children with spastic diplegia. One hundred three of them showed a turning inwards patella during gait (206 lower limbs). Data collected were: hip range of motion, femoral anteversion, spasticity and tightness of internal rotators, patella orientation, hip and pelvis kinematics at mid stance.

RESULTS

One hundred forty nine lower limbs showed excess of femoral anteversion (72%). Among patients with excessive femoral anteversion, only 66 had kinematic internal hip rotation. Other causes were: internal pelvic rotation, isolated spasticity and/or retraction of medial rotator muscles.

DISCUSSION & CONCLUSIONS

Observational gait analysis was not sufficient to identify pelvic rotational troubles. The lack of kinematic data could conduct to a misinterpretation of turning inwards patella gait. Turning inwards patella during gait do not necessarily means excessive femoral anteversion and excessive femoral anteversion do no necessarily results in turning inwards patella gait. 3D gait analysis is an essential tool to complete physical examination. It should help therapeutic decisions and limit the errors in diagnosis.

REFERENCES

Dreher T, Wolf S, Braatz F, Patikas D, Döderlein L. Internal rotation gait in spastic diplegia—Critical considerations for the femoral derotation osteotomy. Gait & Posture. 2007 juin;26(1):25–31.

DeLuca PA, Davis RB 3rd, Ounpuu S, Rose S, Sirkin R. Alterations in surgical decision making in patients with cerebral palsy based on three-dimensional gait analysis. J Pediatr Orthop. 1997 oct;17(5):608–14.

Kay RM, Rethlefsen S, Reed M, Do KP, Skaggs DL, Wren TAL. Changes in pelvic rotation after soft tissue and bony surgery in ambulatory children with cerebral palsy. J Pediatr Orthop. 2004 juin;24(3):278–82.

Ounpuu S, DeLuca P, Davis R, Romness M. Long-term effects of femoral derotation osteotomies: an evaluation using three-dimensional gait analysis. J Pediatr Orthop. 2002 avr;22(2):139–45.

O'Sullivan R, Walsh M, Hewart P, Jenkinson A, Ross L-A, O'Brien T. Factors associated with internal hip rotation gait in patients with cerebral palsy. J Pediatr Orthop. 2006 août;26(4):537–41.

Kim H, Aiona M, Sussman M. Recurrence after femoral derotational osteotomy in cerebral palsy. J Pediatr Orthop. 2005 déc;25(6):739–43.

Wren TAL, Otsuka NY, Bowen RE, Scaduto AA, Chan LS, Sheng M, et al. Influence of gait analysis on decision-making for lower extremity orthopaedic surgery: Baseline data from a randomized controlled trial. Gait & Posture. 2011 juill;34(3):364–9.

Filho MC de M, Yoshida R, Carvalho W da S, Stein HE, Novo NF. Are the recommendations from three-dimensional gait analysis associated with better postoperative outcomes in patients with cerebral palsy? Gait Posture. 2008 août;28(2):316–22.

COMPARISON BETWEEN A NEW DYNAMIC POSTURE ASSESSMENT AND GAIT IN CHILDREN WITH BRAIN DAMAGE

Maurizio Petrarca[1], Fabrizio Patanè[2], Stefano Rossi[2], Sacha Carniel[1], Paolo Cappa[2] and Enrico Castelli[1]

[1]"Bambino Gesù" Children's Hospital, IRCCS, Movement Analysis and Robotic Laboratory (MARLab) - Pediatric Neuro-Rehabilitation Division, Rome, Italy
[2]"Sapienza" University , Department of Mechanical and Aerospatial Engineering, Rome, Italy

INTRODUCTION

Instrumental assessment of balance and Centre of Pressure (CoP) is not yet a routine procedure in clinical practice [1] and is not suitable to significantly influence the clinical decision making in individual patients [2]. This is mainly due to the complexity of the task, that depends on multi-joint coordination and multiple solutions [3]. So, the practical and theoretical importance to associate postural control on moving platform and gait is recommended [4].

PATIENTS/MATERIALS and METHODS

A surface pressure matrix (Matscan) and a robotic 3D rotational platform (RotoBiT3D) were utilized to assess CoP variations in static and dynamic conditions. CoP position was acquired at the frequency of 100 Hz during three repeated trials lasting 30 s each, in dynamic and static condition on 29 subjects with brain damage (mean age 10±5 years, 12 with atassia, 6 with hemiplegia, 11 with diplegia). Static condition implied stable surface of support. Dynamic conditions consisted in maintaining upright position on the platform controlled in impedance with horizontal point of equilibrium and elastic constant normalized in respect to the height and the weight of the patients, in order to assure comparable level of difficulty. CoP indicators were calculated and Anova test was conducted. Gait analysis was achieved by mean of an optoelectronic system (Vicon Mx).

RESULTS

The length, the velocity and the sway area of the CoP, were higher in dynamic conditions than in static one. Instead, mean frequency of oscillation did not show statistical difference, although showed a tendency to decrease from patients with ataxia to those with hemiplegia and to those with diplegia. High walking velocity was associated with high oscillation frequency in static condition, while in dynamic condition high walking velocity was associated with low frequency of oscillation.

DISCUSSION & CONCLUSIONS

The stability of the mean frequency of oscillation both in static and dynamic conditions observed in respect to the variation of the other variables may suggests that it be considered an important control variable used by the nervous system to stabilize upright posture. The observed trend of high gait velocity associated to the low frequency of oscillations only in dynamic condition, suggests that the dynamic context utilized elicits, in the examined subjects, a more reliable upright balance capacity. The proposed dynamic protocol appears a useful sensitive test for postural assessment.

REFERENCES

1. Nardone A, Schieppati M. The role of instrumental assessment of balance in clinical decision making. Eur J Phys Rehabil Med 2010; 46: 231-37.

2. Visser JE, *et al.* The clinical utility of posturography. Clinic Neurophysiol 2008; 119: 2424-36.

3. Hsu W, et al. Control and Estimation of Posture During Quiet Stance Depends on Multijoint Coordination. J Neurophysiol 2007; 97: 3024–3035.

4. Evans MK, Krebs DE. Posturography does not test vestibulospinal function. Otolaryng Head Neck 1999; 120(2): 164-73.

DEFICITS IN ANTICIPATORY INHIBITION OF POSTURAL MUSCLE ACTIVITY ASSOCIATED WITH LOAD RELEASE WHILE STANDING IN INDIVIDUALS WITH SPASTIC DIPLEGIC CEREBRAL PALSY

Hidehito Tomita[1], Yoshiki Fukaya[2], Yuri Tsukahara[1], Kenji Totsuka[1], Yoshiji Yamamoto[2] and Katsuyoshi Shionoya[2]

[1]Toyohashi SOZO University, Department of Physical Therapy, Toyohashi, Japan
[2]Aichi Prefectural Hospital and Rehabilitation Center for Disabled Children, Dai-ni Aoitorigakuen, Okazaki, Japan

INTRODUCTION

It is well known that anticipatory activation and inhibition of postural muscles play an important role in maintaining postural equilibrium during voluntary movement while standing. Recently, we reported that individuals with spastic diplegic cerebral palsy (SDCP) exhibit several deficits in anticipatory activation of postural muscles, which is likely to result in a larger disturbance of postural equilibrium [1,2]. However, no previous studies have examined anticipatory inhibition of postural muscles in individuals with SDCP. This study aimed to determine whether individuals with SDCP have deficits in anticipatory inhibition of postural muscle activity.

PATIENTS/MATERIALS and METHODS

Nine individuals with SDCP (SDCP group, 3 females and 6 males, 13–24 years of age) and 9 age- and gender-matched individuals without disability (control group) participated in this study. Participants stood on a force platform, which was used to measure the position of the center of pressure (CoP), while holding a load in front of their bodies. They then released the load by abducting both shoulders. The load release was conducted under two different load conditions. Surface electromyograms were recorded from the rectus abdominis, erector spinae (ES), rectus femoris (RF), medial hamstring (MH), tibialis anterior (TA), and gastrocnemius (GcM) muscles.

RESULTS

In the control group, anticipatory inhibition before load release and load-related modulation of the inhibition were observed in all the dorsal muscles recorded (ES, MH, and GcM). In the SDCP group, similar results were obtained in the trunk muscle (ES), but not in the lower limb muscles (MH and GcM). Anticipatory activation of the ventral lower limb muscles (RF and TA) and load-related modulation of the activation were observed in both participant groups. CoP path length during load release was longer in the SDCP group than in the control group.

DISCUSSION & CONCLUSIONS

The present findings suggest that individuals with SDCP exhibit a lack of anticipatory inhibition of postural muscles at the dorsal part of the lower limbs, which is likely to result in a larger disturbance of postural equilibrium.

REFERENCES

[1] Tomita H, Fukaya Y, Honma S, Ueda T, Yamamoto Y, Shionoya K. Anticipatory postural muscle activity associated with bilateral arm flexion while standing in individuals with spastic diplegic cerebral palsy: A pilot study. Neurosci Lett 2010;479:166–70.

[2] Tomita H, Fukaya Y, Ueda T, Honma S, Yamashita E, Yamamoto Y, Mori E, Shionoya K. Deficits in task-specific modulation of anticipatory postural adjustments in individuals with spastic diplegic cerebral palsy. J Neurophysiol 2011;105:2157–68.

DIFFERENCES IN JOINT MOMENTS IN HEMIPLEGIC CHILDREN DUE TO MRI-BASED SEGMENT PARAMETERS

Timothy A Niiler[1] and Jacques Riad[2]

[1]Penn State Brandywine, Department of Physics, Media, PA, USA
[2]Orthopaedic Department Skövde, Stockholm, Sweden

INTRODUCTION

Recent work has confirmed that limb segment parameters such as relative location of center of mass (COM), fractional body mass (FBM), and moment of inertia (MI) are important in the calculation of joint moments in gait data [1][2]. However, most gait analysis programs use the same limb segment parameters regardless of patient pathology. In children with hemiplegic CP the clear size and mass differences from affected to unaffected side [3] invokes a need to investigate the effect these parameters have clinically.

PATIENTS/MATERIALS and METHODS

Subsequent to obtaining IRB approval, retrospective MRI data from 9 hemiplegic subjects were used to calculate shank segment parameters including COM, FBM, and distal moments of inertia (MI), where I_{xx} is the flexion MI, I_{yy} is the adduction MI, and I_{zz} is the rotation MI. Comparisons of MI between affected and unaffected legs were conducted using paired, one-tailed t-tests and linear regression. Average parameters for the unaffected and affected legs were then used in OrthoTrak (OT) to compute flexion joint moments at the knee for a convenience sample of 7 additional hemiplegic subjects for whom there was gait data. Affected leg moments computed using each set of parameters were compared to each other at each point of the gait cycle on a per subject basis using t-tests.

RESULTS

For every subject the MI were significantly larger for the unaffected legs than for the affected legs. Regression of affected versus unaffected sides resulted in significant ($p < 0.005$) correlations of 0.924, 0.922, and 0.704 for flexion, abduction, and rotational MI respectively. Likewise, the FBM was significantly greater for the unaffected leg. However, there was no significant difference in any part of the gait cycle between knee flexion moments computed using segmental parameters derived from affected legs compared to unaffected legs. Where largest differences did occur early in double support, the maximum difference in magnitude of peak moments was only 15% for flexion moments.

	COM (%prox)	FBM (%)	Ixx (kg m^2)	Iyy (kg m^2)	Izz (kg m^2)
CP Affected	39.3±0.7	3.7±0.4	0.0429±0.0110	0.0442±0.0104	0.0039±0.0010
CP Unaffected	40.0±1.2	4.2±0.4	0.0505±0.0146	0.0502±0.0145	0.0048±0.0014

DISCUSSION & CONCLUSIONS

At first glance, there is no clinical difference in moments regardless of the method of calculation. However, it must be remembered that these results are for a *single segment* and that moments have an effect that is additive from the ankle to the hip. Due to this cumulative effect, it is likely that if the foot and thigh have similar differences to what is seen here, there will likely be a clinically notable difference in hip joint moments. Because there are differences between computational methods, and it is possible to predict leg-to-leg differences in segmental parameters [4], it seems prudent to begin considering the implementation of these results in calculations for the sake of accuracy. Further work will entail quantification of segmental parameters for the foot and the thigh.

REFERENCES

[1] Ganley KJ, Powers CM. Clinical Biomechanics 19 (2004).
[2] Rao G, Amarantini D, Favier D. Journal of Biomechanics 39, 8 (2005).
[3] Zonta MB, et al. Rev. paul. pediatr. 27, 4 (2009).
[4] Niiler TA, Riad J. GCMAS (2012).

IMPROVEMENT OF HEMIPLEGIC PATIENT´S GAIT PATTERN OVER 8-MONTH PERIOD AFTER PLANTARFLEXORS FACIOTOMY. A CASY STUDY.

Mari Alvela[1, 2], Margot Pintson[1, 2], Kadri Englas[1, 2], Ulle Kruus[1, 2], Priit Eelmae[1, 2, 3]

[1]Haapsalu Neurological Rehabilitation Centre, Clinical Gait Lab, Haapsalu, Estonia
[2]Centre of Excellence in Health Promotion and Rehabilitation, Haapsalu, Estonia
[3]University of Tartu, Institute of Exercise Biology and Physiotherapy, Haapsalu, Estonia

INTRODUCTION

Clinical gait analysis (CGA) was conducted on an 8-year old female patient with spastic right hemiplegia (cerebral palsy, CP). The main problem of the patient is extremely tight Achilles tendon. Achilles tendon lengthening was done in early childhood, with no positive results. In addition, pre-faciotomy leg length discrepancy was 2,5 cm, resulting with posture problems. CGA was conducted pre-operatively, 1 month, 4 months and 8 months following faciotomy. The first two analysis were made barefoot, the last analysis was done with footwear, with correction for leg length discrepancy. After the surgery, the patient received three intensive rehabilitation periods, each lasted two weeks. In addition she had 20 robot-assisted treadmill training sessions and home exercises. The aim of this paper is to describe the changes of gait pattern over time after plantarflexors faciotomy of hemiplegic patient.

PATIENTS/MATERIALS and METHODS

3D Vicon Gait Analysis System (8 Vicon MX-T20 cameras, 2 Basler cameras) and two AMTI dynamographic platforms were used to capture the data. Markers were placed according to Davis model. Before the gait analysis physiotherapeutic assessment was carried out. All assessments and gait data collection was carried out within one day by two physiotherapists. Data was captured with Vicon Nexus 1.7.1 software and presented for interpretation with Vicon Polygon 3.5.1 software. For interpretation 3 good gait trials were selected.

RESULTS

Before the surgery, there was a severe plantarflexion (over 25°) at initial contact on the right side. Plantarflexion lasted throughout the whole gait cycle, with no active dorsiflexion in swing phase. Push-off values for the right ankle were close to zero. One month post-op analysis showed great improvement of ankle dorsi-plantarflexion movement. Initial contact was still made with ankle in plantarflexion, but the range was less than 10°. The graph has moved close to zero-line, with drop-foot in the swing phase. The pattern on ankle power graph is close to normal, but values are minimal. 8-month post-op analysis showed improvement from mid-stance to toe-off; the patient has achieved 2nd and 3rd rocker. Initial contact is still made with ankle in plantarflexion and drop-foot continues because there is no active dorsiflexion. Push-off values on the ankle power graph have increased up to about 1/3 of estimated values.

DISCUSSION & CONCLUSIONS

The faciotomy has been effective for improving the gait pattern of hemiplegic patient. Position of the right foot improved greatly. There was a great difference in the ankle joint position at the initial contact pre and post-op, but almost no change occurred during 1-month and 8-month follow-up studies due to no active dorsiflexion. Furthermore, drop-foot in the swing phase retained. Because of no further improvement in swing-phase and initial contact, AFO was recommended to support the dorsiflexion of right ankle. The push-off values increased constantly. The faciotomy showed good results in improving gait pattern an CGA is a good tool to describe and evaluate the efficacy of chosen intervention.

REFERENCES

MODULATION ABILITY OF AUTOMATIC POSTURAL RESPONSE IN INDIVIDUALS WITH SPASTIC DIPLEGIC CEREBRAL PALSY

Etsuko Mori[1], Hidehito Tomita[1], Akira Kanai[1], Yoshiki Fukaya[2], Daisuke Kawaguchi[1] and Akiyoshi Watanabe[3]

[1]Toyohashi SOZO University, Graduate School of Health Sciences, Toyohashi, Japan
[2]Aichi Prefectural Hospital and Rehabilitation Center for Disabled Children, Dai-ni Aoitorigakuen, Okazaki, Japan
[3]Koseikai Akaiwaso, Toyohashi, Japan

INTRODUCTION

Roncesvalles et al. [1] examined automatic postural response to support surface translation in individuals with spastic diplegic cerebral palsy (SDCP) and reported that individuals with SDCP appear to have difficulty modulating postural muscle activity to fit changes in the velocity and amplitude of the translation. Since this study only recorded lower leg muscle activity, it is unclear whether individuals with SDCP have the ability to modulate thigh and trunk muscle activity. The present study aimed to examine this possibility by recording postural muscle activity in the trunk and lower limbs during platform perturbations.

PATIENTS/MATERIALS and METHODS

In this study, participants were 7 individuals with SDCP (SDCP group, 2 females and 5 males, 14-24 years of age) and 7 age- and gender-matched individuals without disability (control group). All participants in the SDCP group were rated as level II on the Gross Motor Function Classification System. Participants stood on a platform that moved transiently in the backward direction. The perturbations were conducted under two different conditions (easy: 4 cm at 15 cm/s; difficult: 8 cm at 25 cm/s). Surface electromyograms were recorded from the rectus abdominis, erector spinae (ES), rectus femoris, medial hamstring (MH), tibialis anterior, and gastrocnemius (GcM) muscles. The center of pressure in the anteroposterior direction (CoPy) during the perturbation was also recorded.

RESULTS

The onset latency of GcM was significantly later in the SDCP group than in the control group, although no significant differences were found in ES or MH between the two groups. In both groups, response amplitudes in ES, MH, and GcM were significantly larger in the difficult condition than in the easy condition. Although the degree of modulation in GcM was significantly smaller in the SDCP group than in the control group, no significant differences were found in the degree of modulation in ES or MH between the two groups. In both perturbation conditions, the peak CoPy displacement after the perturbation was significantly larger in the SDCP group than in the control group.

DISCUSSION & CONCLUSIONS

This is the first study to demonstrate that individuals with SDCP appear to have the ability to modulate tight and trunk muscle activity to fit task conditions. However, the degree of modulation in the SDCP group was not as much as in the control group, and the peak CoPy displacement was larger in the SDCP group. These results suggest that an increase in tight and trunk muscle activity is insufficient to compensate for a delayed onset latency of lower leg muscle activity and a lack of modulation of lower leg muscle activity, resulting in a larger disturbance of postural equilibrium.

REFERENCES

[1] Roncesvalles MN, Woollacott MW, Burtner PA. Neural factors underlying reduced postural adaptability in children with cerebral palsy. Neuroreport 2002;13:2407–10.

PREDICTION OF SITE OF BOTULINUM TOXIN MULTILEVEL BASED ON GAIT PARAMETERS. A PILOT STUDY

Irene Pulido-Valdeolivas[1], David Gómez-Andrés[1], Aitor Cinza[1], Gabriel Liaño[1], Lorena Martín-Román[1], Javier López[2], Samuel Ignacio Pascual-Pascual[1] and Estrella Rausell[1]

[1]Trastornos del Desarrollo y Maduración Neurológica. IdiPaz. Universidad Autónoma de Madrid.
[2]Hospital Universitario Infanta Sofía, Rehabilitación, S.S. de los Reyes (Madrid)

INTRODUCTION

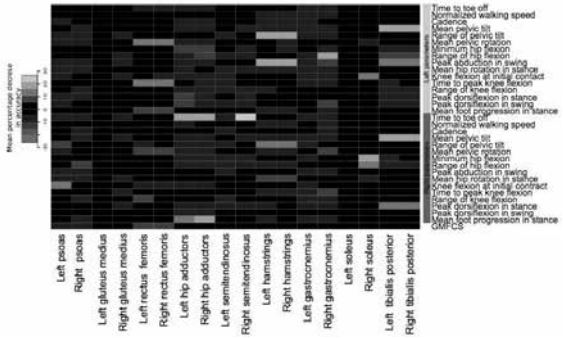
Multilevel injection of botulinum toxin type A (MIBT) is a frequent treatment for spasticity in cerebral palsy (CP). The planning of muscles to be injected is based on clinical parameters. Neither common pre-treatment studies nor standard decision protocols exist. The objective of this study is to determine the influence of pre-treatment gait pattern in injection planning in order to assess the potential role of instrumental gait analysis in MBTI decision-making.

PATIENTS/MATERIALS and METHODS

17 school-aged children affected by spastic CP with predominant affection of lower limbs (GMFCS I-III, MACS I-II, CFCS I) who were going to be injected were selected. The 16 left and the 16 right kinematic parameters used to calculate Gillette Gait Index were measured in each child before injection. Their values were expressed in Z-score according to a reference dataset of normal school-aged children. Muscles to be injected were determined by clinical expertise without information provided by gait analysis. Random forests were trained by using GMFCS and the 32 gait parameters as independent variables. Goodness of fit of each one was estimated by the area under ROC and the influence of each dependent variable in each model was estimated by mean percentage of decrease in model accuracy when variable is out of the bag.

RESULTS

Our predictive model only was better than randomness in left and right rectus femoris muscles and left and right hamstrings. The following figure is a heatmap that shows importance of each dependent variable in each muscle model. The greener the square, the more positive the importance, which means that values of that variable are more related with decision-making in that particular muscle.



DISCUSSION & CONCLUSIONS

Small sample size and the limited number of gait parameters that can be used are the main internal limitations of our study. However, low correlation among decision and gait parameters shows that gait analysis has still a potential role to plan MTBI.

REFERENCES

[1] Liaw A et al. Classification and regression by random Forest. R News 2003; 2/3. [2] Pulido-Valdeolivas I et al. Parámetros de marcha en una muestra de referencia de escolares sanos españoles. Neurologia 2012; accepted.

QUANTITATIVE PARAMETERS TO DEFINE THE ANGLE AND SEVERITY OF THE CATCH IN CHILDREN WITH SPASTIC CEREBRAL PALSY.

Lynn Bar-On[1], Erwin Aertbeliën[2], Davide Monari[2], Anne Cazaeck[1], Guy Molenaers[3, 1], Kaat Desloovere[1, 3]

[1]KU Leuven, Rehabilitation Sciences, Leuven, Belgium
[2]KU Leuven, Mechanical Engineering , Leuven, Belgium
[3]University Hospital Pellenberg, CMAL, Pellenberg, Belgium

INTRODUCTION

The angle at which a clinician encounters a catch sensation during a fast stretch of a spastic muscle is called the angle of catch (AOC). The AOC is commonly measured using the Tardieu Scale (TS)[1], a subjective scale whose reliability or validity have been questioned[2]. Biomechanical techniques based on individual signal data (angular deceleration[2] and torque[3]) have recently been suggested as objective alternatives to define the AOC. However, we believe that integration of all signals may provide an improved quantification of the AOC, as well as additional measures for the severity of a catch. A new objective definition and severity indicator, which combines both torque and angular velocity, is introduced: the angle corresponding to the time of maximal power absorption. The psychometric properties of different AOC definitions and severity indicators were explored in two spastic muscles in children with cerebral palsy (CP).

PATIENTS/MATERIALS and METHODS

The gastrocnemius (GAS) and medial hamstrings (MEH) of 46 children with CP (9±3.3 years, 22 males) were stretched by passively moving the knee or ankle joint through the full range of motion (ROM) as fast as possible. Twelve children were re-tested after 11.6±7.9 days. During the stretches, joint angle characteristics, torque, and surface EMG (sEMG) were simultaneously collected. AOC 1, 2 and 3 were estimated based on maximum angular deceleration[2], maximum change in torque (dT/dt)[3] and maximal power absorption respectively. AOC 1, 2 and 3 were expressed as a percentage of the full ROM. Between session repeatability was calculated by ICC (1, k) and SEM[4]. To explore validity, parameters were compared using Spearman's rank order correlations to the averaged root mean square sEMG (rms EMG) and to the value of the TS[1].

RESULTS

For both muscles, repeatability of all three AOC definitions were high with the exception of AOC2 in the MEH. Neither muscle showed a correlation between maximum deceleration and maximum dT/dt. AOC3 significantly correlated to the TS in both muscles. For the MEH, AOC3 showed the highest correlation to rms EMG (Table 1).

Table 1: ICC and Spearman's rank correlation coefficients of selected parameters

	GAS						MEH					
	AOC1	AOC2	AOC3	Max. deceleration	Max. dT/dt	Min. power	AOC1	AOC2	AOC3	Max. deceleration	Max. dT/dt	Min. power
ICC	0.95	0.94	0.94	0.25	0.91	0.84	0.98	0.59	0.97	0.69	0.20	0.60
rms EMG	0.11	0.03	-0.06	0.09	-0.30	**-0.35***	**-0.55***	**-0.32***	**-0.62***	0.10	0.04	0.20
TS	0.21	0.11	**0.30***	-0.03	0.19	0.20	0.42	-0.02	**0.45***	0.02	**-0.53***	-0.01

***p<0.05 Spearmans' rank correlation.**

DISCUSSION & CONCLUSIONS

The AOC can be quantified in a repeatable way in a clinical setting for the GAS and MEH of children with CP. The low correlation between maximum deceleration and maximum dT/dt emphasizes the need to define and quantify the severity of the AOC based on an integration of signals. A change in the direction of the power best represents the definition of the AOC. In addition, low correlations between signals indicate the need to examine EMG information in order to fully understand the AOC and link it to spasticity. The sensitivity of AOC3 to spasticity treatment should be explored.

REFERENCES

1.Tardieu G. et al. Rev Neurol (Paris) 1954;91:143-4. 2.Van den Noort J. et al. G & P 2009;30:138–43. 3.Wu Y. et al. Develop Med & Child Neurol 2010;52:563-9. 4.Weir JP. J Strength Cond Res 2005;19:231-40.

EFFECT OF TREADMILL GAIT TRAINING ON STATIC AND FUNCTIONAL BALANCE IN CHILDREN WITH CEREBRAL PALSY: RANDOMIZED CONTROLLED CLINICAL TRIAL

Daniela Aparecida Biasotto-Gonzalez[1], Luanda Collange Grecco[1], Hugo Pasini Neto[2], Cid André Fidelis de Paula GOMES[3], Luciana Maria Malosa Sampaio Jorge[1] and Claudia Santos Oliveira[2]

[1]July Nine University , Master of Rehabilitation Sciences, São Paulo, Brazil
[2]July Nine University , Master and Doctor of Rehabilitation Sciences, São Paulo, Brazil
[3]July Nine University , Physiotherapy, São Paulo, Brazil

INTRODUCTION

Gait training on a treadmill is currently the focus of study as a therapeutic resource in the rehabilitation of children with cerebral palsy, but little is known regarding its effect on static and functional balance in these children[1,2]. The aim of the present study was to carry out a comparative analysis of the effects of gait training on a treadmill and on the ground in children with cerebral palsy

PATIENTS/MATERIALS and METHODS

A randomized, controlled, clinical trial with a blinded evaluator was carried out involving children with cerebral palsy between three and 12 years of age and categorized in Levels I to III of the Gross Motor Function Classification System. Assessments were performed before and after the intervention and involved the Berg balance scale as well as the determination of oscillations from the center of pressure in the anteroposterior and mediolateral directions with eyes open and closed. The experimental group was submitted to gait training on a treadmill and the control group performed gait training on the ground. The intervention consisted of two 30-minute sessions per week for seven weeks

RESULTS

Both groups exhibited better functional balance after the protocols. The experimental group had higher scores on the Berg balance scale and exhibited lesser mediolateral oscillation with eyes open in comparison to the control group

	Experimental group		Control group	
	Before	After	Before	After
AP oscillation EO (cm)	1.1 (1.0 – 1.2)	1.0 (1.0 – 1.1)*	1.1 (1.0 – 1.2)	1.0 (1.0 – 1.1)*
AP oscillation EC (cm)	1.4 (1.1 – 1.7)	1.3 (1.0 – 1.6)	1.2 (1.1 – 1.2)	1.1 (1.1 – 1.1)
ML oscillation EO (cm)	4.2 (3.4 – 5.0)	2.1 (0.8 – 3.5) */**	3.6 (2.3 – 5.0)	3.9 (3.4 – 4.4)
ML oscillation EC (cm)	5.0 (4.5 – 5.5)	3.5 (1.6 – 5.3)	4.2 (2.6 –5.9)	4.1 (1.6 – 5.3)

Legend: AP: anteroposterior; ML: mediolateral; EO: eyes open; EC: eyes closed; * dependent t-test ($p < 0.05$); ** independent t-test ($p < 0.05$)*

DISCUSSION & CONCLUSIONS

Gait training on a treadmill had a greater effect on static balance and mediolateral oscillation in comparison to gait training performed on the ground among children with cerebral palsy.

REFERENCES

[1] Richards CL, Malouin F, Dumas F, Marcoux S, Lepage C, Menier C. Early and intensive treadmill locomotor training for young children with cerebral palsy: A feasibility study. Pediatric Phys The. 1997; 9(4):158–65.
[2] Johnston TE, Watson KE, Ross SA et al. Effects of a supported speed treadmill training exercise program on impairment and function for children with cerebral palsy. Dev Med Child Neurol 2011; 53(8):742-50.

OUTCOMES OF RECTUS FEMORIS TRANSFERS IN CHILDREN WITH CEREBRAL PALSY: EFFECT OF TRANSFER SITE

Andi B Gordon[1], Mark L McMulkin[1], William F Scully[1], Brian J Tompkins[1], Glen O Baird[1] and Paul M Caskey[1]

[1]Shriners Hospitals for Children, Spokane, USA

INTRODUCTION

Distal rectus femoris transfer is a widely accepted and effective treatment for children with cerebral palsy with a stiff knee gait. Previous research has reported equivalent improvement in knee arc of motion regardless of transfer site - four locations [1]; however, sample sizes between groups were quite different. The purpose of this study was to compare the outcomes of children with cerebral palsy treated with a distal rectus femoris transfer for stiff knee to one of three sites: medial to the semitendinosus, medial to the sartorius or lateral to the iliotibial band.

PATIENTS/MATERIALS and METHODS

Following ethics board approval for this Retrospective Cohort Study, the Motion Analysis Laboratory database was queried for all subjects with cerebral palsy who had pre- and post-operative gait analysis studies and a rectus femoris transfer (as part of their surgical intervention). The iliotibial band (ITB) group was the smallest group of subjects identified with 14 participants (20 limbs); in the sartorius (SR) group, 24 individuals (40 limbs) were identified and in the semitendinosus (ST) group 56 individuals (95 limbs) were identified. The SR and ST groups sample sizes were reduced to match both the size and proportion of GMFCS Levels to the ITB group. All groups had a sample size of 20 limbs; GMFCS I=2, II=5-6, III=12-13. All participants completed a gait analysis study including 3-D kinematics. Pre- and post-operative kinematic knee variables were generated. Each variable was compared using a two factor ANOVA with significance set at 0.05. The first factor was transfer site with three levels and the second repeated measures factor had two levels of pre/post-surgery.

RESULTS

There were no significant differences between the three rectus femoris transfer groups pre-operatively on knee gait variables $p > 0.05$. Pre- to post-operative, there were significant improvements for all three groups in gait on knee arc of motion of 11, 12, and 12 degrees for the ITB, SR, and ST groups respectively, $p < 0.05$. There were also significant improvements in timing of peak knee flexion in swing, and knee extension at initial contact for all three groups. There were no significant differences between the three groups in magnitude of improvement.

DISCUSSION & CONCLUSIONS

Regardless of transfer site of the rectus femoris, there were no differences in the kinematic outcomes for children with cerebral palsy. All three rectus femoris transfer sites resulted in significant improvements in gait on knee arc of motion, timing of peak knee flexion in swing, and knee extension at initial contact with similar magnitudes. Distal rectus transfer is an effective procedure for treating the stiff-knee gait in cerebral palsy. The location site of the transfer resulted in equally beneficial outcomes and can be based on surgeon preference and concomitant procedures.

REFERENCES

[1] Ounpuu S et al, 1993, J Pediatr Orthop, 13:325-30

REPEATED INJECTIONS WITH BOTULINUM TOXIN A TO IMPROVE GAIT, EVALUATED BY MUSCLE SPECIFIC OUTCOME MEASURE, IN CHILDREN WITH CEREBRAL PALSY

Katrien Fagard[1], Kaat Desloovere[1, 2], Anja Van Campenhout[3], Nathalie Van De Poel[1], Davide Monari[4], Guy Molenaers[3]

[1]C-MAL, University Hospital, Pellenberg, Belgium
[2]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[3]KU Leuven, Department of Musculoskeletal Sciences, Leuven, Belgium
[4]KU Leuven, Department of Production engineering, Machine design and Automation, Leuven, Belgium

INTRODUCTION

While BTX-A is increasingly being used to treat spasticity in children with cerebral palsy (CP), the effect decreases with increased number of treatments, mainly from the 3rd or 4th treatment.[1] It is believed that repeated BTX-A treatments should be more focused and integrated with specific physiotherapy to remain successful. The aim of this study was to evaluate whether this decreasing effect of repeated BTX-A injections could be influenced by goal oriented treatment with increased involvement of the physiotherapist.

PATIENTS/MATERIALS and METHODS

Ten CP children, with a history of at least 4 lower limb BTX-A treatments, were included. For these children, the new BTX-A was set-up according to a targeted goal oriented treatment. Treatment goals were carefully selected, based on gait analysis and clinical evaluation. Innovative for this new treatment was that these specific treatment goals and the resulting muscle selection for injection were clearly documented to and discussed with the child's physiotherapist, who was encouraged to give special attention to these goals during the 2 months post BTX-A period. Achievement of treatment goals was scored based on comparison of pre and 2 months post BTX-A gait analysis. Goals were linked to specific gait parameters, automatically extracted from gait continuous waveforms. Z-scores were determined for each extracted parameter, based on pediatric typical reference data (Z=(mean CP child–mean typical children)/SD typical children). The median |Z-score| was calculated separately for goals related to psoas, hamstrings and gastrocnemius injection. Subsequently, a percentage of change score was calculated for each median Z-score (=(|Zpre|-|Zpost|)/|Zpre|). Wilcoxon signed ranked test was used to compare the percentage of change score of the last with the previous treatment.

RESULTS

Overall, the effect of the last treatment did not significantly change with respect to the previous. For 8 of the 9 patients injected in the hamstrings, we could compare the results of the targeted treatment with the previous injection. Six of these 8 patients were injected bilaterally. The mean percentage of change score increased from -5% to 8%, suggesting an improved effect of BTX-A for the last compared to the previous treatment. However, due to large intersubject variability, this increase was not significant ($p=0.36$). The gastrocnemius muscle was injected in 5 patients. For 3 patients (1 injected bilaterally, 2 unilaterally), we had gait analysis results of their previous injection in this muscle. The mean percentage of change score increased from 25% to 33%, indicating that they had still benefited from injections. For 3 of the 7 patients injected in the psoas muscle, results of previous BTX-A treatment in this muscle were available. They were all injected bilaterally. The mean percentage of change score significantly decreased from 11% to -17%, indicating decreased effect of BTX-A ($p=0.03$). The percentage of change score did not correlate with age and the presence of contractures.

DISCUSSION & CONCLUSIONS

The current results suggest that 4 or more repeated injections in the hamstrings and gastrocnemius can still be effective when the physiotherapists are involved in the treatment plan and are well informed about the treatment goals. For the psoas, the modified treatment strategy did not result in an improved effect.

REFERENCES

1 Molenaers et al(2008);Gait&Posture28(2):S1

DISTRIBUTION OF GAIT ABNORMALITIES IN VERY YOUNG CHILDREN WITH BILATERAL SPASTIC CP ACCORDING TO THE MODIFIED AMSTERDAM GAIT CLASSIFICATION.

Marcin Bonikowski[1], Anna Czernuszenko[2], Jakub Gąsior[3] and Mariusz Pawłowski[2]

[1]Mazovian Neurorehabilitation and Psychiatry Center, Rehab. Department, Movement Analysis Lab., Warsaw, Poland
[2]Mazovian Neurorehabilitation and Psychiatry Center, Rehab. Department, Zagórze n. Warsaw,, Poland
[3]Warsaw Medical University, Warsaw, Poland

INTRODUCTION

Gait abnormalities are present at a very early age in children with CP. Modified Amsterdam Gait Classification (MAGC) was developed on the basis of oryginal AGC (1) by the authors. Aim: To describe prevalence of different gait types according to the MAGC in the youngest walkers with bilateral spastic CP.

PATIENTS/MATERIALS and METHODS

We analysed gait using 2D video recording in 75 children (150 legs) with spastic diplegia younger than 3 years GMFCS level II-IV selected for spasticity treatment with Botulinum Toxin. Gait type was described using the MAGC: MidStance abnormalities:

Type 1 - normal.

Type 2 - Knee (hyper)extension without heel rise (HR)

Type 3 - Knee (hyper)extension with HR

Type 4 - Knee flexion with HR

Type 5 - Knee flexion without HR

Swing phase abnormalities:

Type A - dropfoot in midswing

Type B - stiff knee (initial swing knee flexion < 60 degrees, or delayed)

Type C - limited knee extension in terminal swing

Type D - adduction (+ - endorotation) of the hip in terminal swing.

We analysed gait using 2D video recording in 75 children (150 legs) with spastic diplegia younger than 3 years GMFCS level II-IV selected for spasticity treatment with Botulinum Toxin. Gait type was described using the MAGC: MidStance abnormalities:

Type 1 - normal.

Type 2 - Knee (hyper)extension without heel rise (HR)

Type 3 - Knee (hyper)extension with HR

RESULTS

In the study group gait type 2 was represented by 17 legs (11,3%), type 3 in 90 legs (60%) and type 4 in 43 legs (28,6%). Type 1 and 5 were not observed at all.

Swing phase abnormalities A, B, C and D were observed in 107 (71%), 22 (14,6%), 143 (95%) and 92 (61%) legs respectively.

Type A was present in 31% of legs representing type 2, 81% legs with type 3, and 72% with type 4.

Type B was present in 23%, 15% and 7% of legs representing type 2,3 and 4 respectively.

Type C was present in 88%, 92% and 95% of legs representing type 2,3 and 4 respectively.

Type D was present in 47%, 62% and 58% of legs representing type 2,3 and 4 respectively.

DISCUSSION & CONCLUSIONS

Most common gait deviations in the youngest walkers with CP are type 3 {knee (hyper)extension with HR) in stance and type C (limited knee extension in terminal swing) in swing.

 REFERENCES

P47

INTERACTION BETWEEN WALKING SPEED AND SPASTICITY IN CHILDREN WITH SPASTIC HAMSTRINGS

Catherine Huenaerts[1], Lynn Bar-On[2], Guy Molenaers[3], Anja Van Campenhout[3], Hans Wambacq[4], Kaat Desloovere[1, 2]

[1]C-MAL University Hospital, Pellenberg, Belgium
[2]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[3]KU Leuven, Department of Musculoskeletal Sciences, Leuven, Belgium
[4]KU Leuven, Department of Mechanical Engineering, Leuven, Belgium

INTRODUCTION

Walking velocity (WV) is known to influence different gait parameters [1, 2]. Muscle length (ML) and especially lengthening velocity (MLV) increase with WV. Spasticity on the other hand is associated with reduced ML and MLV [1]. Spastic muscles show an increased coupling between EMG activity and MLV [3]. Therefore, we described the effect of walking speed on spastic hamstrings, with a focus on ML, MLV and EMG.

PATIENTS/MATERIALS and METHODS

49 Children with CP (9.8±3years) with a Modified Ashworth Score ≥1.5 for the hamstrings and 14 TD children (10.5±2.4years) received a 3D lower limb gait analysis, including kinematics, kinetics (8 camera Vicon system), EMG of 8 muscles bilateral (Cometa, Wave EMG) and a clinical examination. They were instructed to walk at self-selected speed, faster and as fast as possible without running. To compare both groups, a linear regression model was created which resulted in two non-dimensional gait velocities (v1, v2), used to compare a large set of parameters. Difference scores (DS) between both velocities were calculated. Statistical analysis was done using the Mann-Whitney U test.

RESULTS

During stance at both velocities, the CP group showed more knee flexion at IC ($p<0.001$) and during mid stance ($p<0.01$), increasing with WV. The knee ROM during shock absorption was higher in the TD group. EMG activity in early stance phase was significantly higher in the CP group at v2 ($p<0.05$), corresponding to an increasing maximum hip moment (H1) in CP children, which was not seen in the TD group (DS: $p=0.001$). During swing, the maximum angular extension velocity was significantly higher in the TD group compared to the CP group at v1 and v2 ($p<0.005$), increasing with WV. Maximum MLV showed similar results, with a significant DS ($p<0.005$) indicating a higher increase in the TD group. No difference was seen in the maximum ML between both groups, while total range of ML was significantly higher in TD group at both speeds, with increasing length range at higher WV. EMG activity in swing showed significantly higher activity at v1 for the CP group, but not at v2.

DISCUSSION & CONCLUSIONS

The effect of WV on knee kinematics at IC and mid stance are in accordance to Schwartz [2] and similar for TD and CP children. The increasing hamstrings activity in CP in early stance may be explained by the biomechanical demands (hip moment). In contrast with TD children who mainly use the gastrocnemius at late stance (push-off) to increase WV. In swing, TD children are capable of increasing their angular velocity and MLV more than children with CP. Van der Krogt [1] reported similar results. This confirms the fact that, although CP children are able to increase their MLV, they prefer to stay under their spastic threshold velocity during self-selected WV. The TD group increases their EMG swing phase activity similar as CP children. This can be explained by a higher angular velocity due to the increased WV, demanding more eccentric contraction of the hamstrings to slow down knee extension motion. The difference in influence of WV on spastic hamstrings compared to TD children seems to be most pronounced on MLV, and less on EMG activity. Compared to the influence of WV on the spastic gastrocnemius, the latter showed an increase in EMG activity in swing, which was not seen in the TD group [4].

REFERENCES

[1] Van der Krogt et al, Gait and Posture 2007 & 2009
[2] Schwartz et al, Journal of biomechanics 2008
[3] Crenna, Neurosci Biobehav Rev 1998
[4] Huenaerts et al, ESMAC 2011, Vienna

POSITIVE AND NEGATIVE WORK DURING WALKING IN CHILDREN WITH CEREBRAL PALSY

Patricia Van de Walle[1, 2, 3], Ann Hallemans[1], Guy Molenaers[4], Nele Op de Beeck[1], Kaat Desloovere[2, 3]

[1]Artesis University College, Health Care, Antwerp, Belgium
[2]University Hospital Pellenberg, C-MAL, Pellenberg, Belgium
[3]KULeuven, Rehabilitation Sciences, Leuven, Belgium
[4]University Hospital Pellenberg, Paediatric Orthopedics, Pellenberg, Belgium

INTRODUCTION

In children with cerebral palsy (CP), gait efficiency is decreased. Gait efficiency is usually evaluated by measurement of oxygen uptake per distance walked (oxygen cost, $J.kg^{-1}.m^{-1}$). Oxygen cost estimates total energy expense of walking, but cannot reveal where energy is expended. Mechanical cost ($J.kg^{-1}.m^{-1}$) during walking can provide these insights. Positive and negative net joint work (W_j) can be calculated separately for different body parts and thus help to identify sources of decreased gait efficiency. In typical developing (TD) children, negative W_j decreases with increasing age, where positive W_j seems not prone to maturational changes [1]. Negative work is produced by eccentric muscle contractions by mainly biarticular muscles. In CP it is mostly these biarticular muscles that are affected by spasticity. The purpose of this study was to identify changes in positive and negative W_j in CP and to compare them with TD children.

PATIENTS/MATERIALS and METHODS

Seventeen children with bilateral spastic CP and 25 TD children (5-13 years) underwent a total body 3D gait analysis with collection of bilateral ground reaction forces (Vicon, AMTI forceplates). Mechanical work was estimated by separate integration of positive and negative net joint power profiles [$J.kg^{-1}.s^{-1}$] for neck, shoulders, elbows, wrists, waist, hips, knees and ankles as obtained from the Vicon Plug-in-Gait model [1]. Mechanical cost (work per meter) was obtained by dividing net joint work by stride length and was calculated for the total body (TB), the lower limbs (LL) and for the HAT (Head, Arms, Trunk). W_j in CP and TD was compared with independent student t-test ($p<0.05$).

RESULTS

Positive (+ 0.57 $J.kg^{-1}.m^{-1}$) and negative W_j (+ |0.62|$J.kg^{-1}.m^{-1}$) were significantly increased in CP (Table 1).

A ($J.kg^{-1}.m^{-1}$)	Diplegia	Typical development	p-value
W_j^+ TB	1.68±0.42 (+51%)	1.11±0.17	<0.001
W_j^- TB	-1.57±0.41 (+65%)	-0.95±0.18	<0.001
W_j^+ LL	1.33±0.27 (+34%)	0.99±0.15	<0.001
W_j^- LL	-1.18±0.23 (+46%)	-0.81±0.14	<0.001
W_j^+ HAT	0.35±0.20 (+169%)	0.13±0.05	<0.001
W_j^- HAT	-0.40±0.21 (+167%)	-0.15±0.07	0.001

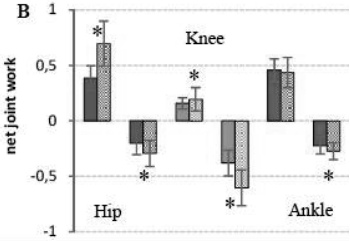


Table 1: Positive and negative W_j for TB, LL and HAT (A) and at hip, knee and ankle for TD (full) and CP (dotted) (B).

DISCUSSION & CONCLUSIONS

Mechanical cost of walking was increased in CP compared to TD peers. The increases in cost were caused by increases in both positive and negative W_j. All three LL joints showed increases in negative work, where the increase in positive W_j was mainly caused by a large increase at the hip. In normal gait, eccentric muscle forces and energy transfer from one segment to the other by biarticular muscles are important to conserve energy during walking. The increases in negative work suggested that a lack of control of these energy conserving mechanisms plays an important role in decreased gait efficiency in CP.

REFERENCES

[1] Van de Walle et al. Gait Posture 2010 (31) 495-501

RELATION BETWEEN BRAIN LESIONS ON MRI AND GAIT PATHOLOGY IN CHILDREN WITH CEREBRAL PALSY.

Leen Van Gestel[1, 2], Els Ortibus[3], Pieter Meyns[4], Paul De Cock[3], Stefan Sunaert[5], Andrea Guzzetta[6], Erwin Aertbeliën[7], Hilde Feys[2], Jaak Duysens[4], Kaat Desloovere[2]

[1]Research assistant of the Research Foundation Flanders
[2]Fac. of Kinesiology and Rehabilitation Sciences, KU Leuven, Dep. of Rehabilitation Sciences, Leuven, Belgium
[3]University Hospitals Leuven, Dep. of Development and Regeneration, Leuven, Belgium
[4]Fac. of Kinesiology and Rehabilitation Sciences, KU Leuven, Dep. of Biomedical Kinesiology, Leuven, Belgium
[5]University Hospitals Leuven, Dep. of Radiology, Leuven, Belgium
[6]Stella Maris Scientific Institute, Dep. of Developmental Neuroscience, Pisa, Italy
[7]Fac. of Engineering, KU Leuven, Production engineering, Machine design and Automation Section, Leuven, Belgium

INTRODUCTION

It is unclear how primary motor deficits and gait pathologies relate to the broad range of brain lesions in children with cerebral palsy (CP). This study combined conventional and innovative MRI imaging modalities evaluating lesions in different brain areas to identify relevant relationships with gait pathology in CP.

PATIENTS/MATERIALS and METHODS

Twenty-five children with spastic diplegia were enrolled according to these inclusion criteria: no surgery or recent BTX-A treatment, data available of (A) 3D gait analysis conducted between 3 and 12y old, and (B) conventional MRI brain scans taken after the age of 3. A subgroup of 14 children also had diffusion tensor imaging (DTI) MRI brain scans. Median spasticity *(modified Ashworth*), and median strength *(manual muscle testing*) of the lower limb muscles (LL), GPS[1]- and GPS-asymmetry scores were extracted from the 3D gait analysis. On conventional MRI scans, the integrity of several structures such as the posterior limb of the internal capsule (PLIC) was evaluated, as well as semi-quantitative scores detailing the severity of the lesion (such as the involvement of the subcortical (SC), middle (M) and periventricular (PV) white matter (WM))[2] and volumetric analyses of e.g. corpus callosum (CC). DTI data reflect the integrity of the corticospinal tract (CST) through fractional anisotropy (FA) and average diffusion coefficients (ADC) calculated over (1) the full course of the CST (CSTf), and (2) its course through the PLIC (CSTp). Additionally, asymmetry indices and sums of the contra- and ipsilateral CSTf/CSTp DTI variables were calculated[3]. Continuous variables were correlated through Spearman correlation coefficients. Continuous variables were related to nominal/ordinal variables through One-way ANOVA's (significance set at $p<.05$).

RESULTS

CC length correlated moderately (r=-0.52), while involvement of the contralateral M WM and the mean CSTf ADC of both sides correlated mildly (r= 0.30/0.31 resp.) with median LL spasticity. Spasticity scores were significantly higher when the PLIC was affected. Correlations of r= 0.32 /-0.35 were found between mean CSTp FA values of both sides / involvement of the contralateral M WM and median LL strength. Involvement of the contralateral SC WM, the mean CSTf FA of both sides, and the mean CSTp FA correlated mildly (0.30 - 0.46) with GPS. When the contralateral PLIC was affected, GPS was significantly higher. GPS asymmetry correlated mildly with CC volume, ventricular volume, asymmetry in mean CSTf FA and asymmetry in mean CSTp ADC values (-0.33 - 0.39). Asymmetric ventricular dilation was associated with higher GPS asymmetries while the opposite was observed for involvement of contralateral SC WM.

DISCUSSION & CONCLUSIONS

This study identified new underlying relationships between the integrity of the contra- and bilateral white matter and motor tracts on the one hand and primary deficits and gait pathologies on the other hand in children with CP.

REFERENCES

[1]Baker et al., 2009; [2]Guzzetta et al., 2010; [3]Bonekamp et al., 2007

RELATIONSHIP BETWEEN PELVIC ANTIVERSION AND TOE-WALKING IN HEALTHY YOUNG PEOPLE AND CHILDREN WITH CEREBRAL PALSY

Maurizio Petrarca[1], Sacha Carniel[1], Alessandra Colazza[1] and Enrico Castelli[1]

[1]"Bambino Gesù" Children's Hospital, IRCCS, Movement Analysis and Robotic Laboratory (MARLab) - Pediatric Neuro-Rehabilitation Division, Rome, Italy

INTRODUCTION

Biomechanical simulations evidenced that gait patterns in children with cerebral palsy depend on multiple resources: neurological on one side and body configurations, muscles and soft tissues changes on the other side[1]. It is known that healthy children, who simulates toe walking, use the same resources of children with cerebral palsy [2]. Toe walking is often associated with anterior pelvic tilt, but which is the contribution of anterior pelvic tilt to toe walking?

PATIENTS/MATERIALS and METHODS

Six healthy young people (age 29±3 years) participated to the present study. Gait analysis (Vicon MX with 8 cameras, two AMTI force plates and Wave wireless EMG) was conducted barefoot along a walkway of about 13 meters. Then, were asked to them to walk rotating the pelvis towards anterior position. Kinematic and kinetic data were retrospectively compared with gait data of 43 children with cerebral palsy.

RESULTS

The pelvis anterior rotation in young people when they simulated anterior pelvic tilt was double than the pelvis rotation during natural walk and the walking cadence increased. While, the shape of the time series of the tilt in young people simulating anterior rotation and children with cerebral palsy showed a similar and in phase double bump. The same shape in the comparison between the two groups of ankle kinematic and kinetic time series was observed. The comparison of the enveloped s_EMG of the triceps between young people simulating pelvic anti-version and children with cerebral palsy evidenced the same anticipated and prolonged activation, during stance phase.

DISCUSSION & CONCLUSIONS

The biomechanical configuration, like the simulation of pelvic anti-version, represent a constrains system that in healthy young can induce a not requested toe-walking. In that perspective, it is possible to hypothesize that toe walking , that it is known as an alternative and immediately available solution for walking, can emerge not only from the inability to selectively control the lower limb, but can also be a consequence of the inability to balance the pelvis over the hip. Similar patterns can origin from different combination of individual global resources that needs to be assessed on each single patient.

REFERENCES

1. Fonseca ST et al. Physycal Therapy 2004;84(4):344-58.
2. Romkes J & Brunner R. Gait Posture 2007;26(4):577-86.

RELIABILITY OF HEAD AND TRUNK KINEMATICS DURING GAIT IN CHILDREN WITH SPASTIC DIPLEGIA

Lieve Heyrman[1], Hilde Feys[1], Guy Molenaers[2, 3], Kaat Desloovere[1, 2], Patricia Van de Walle[2, 4], Davide Monari[5], Erwin Aertbeliën[5], Ellen Jaspers[1]

[1]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[2]University Hospital Pellenberg, CMAL, Pellenberg, Belgium
[3]KU Leuven, Department of Development and Regeneration, Leuven, Belgium
[4]Artesis Hogeschool Antwerpen, Department of Health Care, Antwerpen, Belgium
[5]KU Leuven, Department of Mechanical Engineering, Leuven, Belgium

INTRODUCTION

Whilst 3D analysis has become the standard tool to support lower limb treatment planning in children with CP, the trunk segment has thus far received less attention. Nonetheless, the development of adequate trunk control is found vital to achieve skilled walking.[1,2] Available kinematic trunk models often simplify the trunk into one to three segments and there is a clear lack in consensus regarding segment definitions, marker placement, anatomical coordinate systems and joint conventions.[3] This study proposes a reliable and clinically-oriented model for the 3D analysis of head and trunk movements, including spinal segmental movements.

PATIENTS/MATERIALS and METHODS

Ten children with spastic diplegia (age 6-14yrs) were tested twice, within 4 weeks. Within and between session reliability of head and trunk kinematics was assessed during gait. The kinematic model consisted of five rigid segments (i.e. head, thorax, pelvis, shoulder line, spine), for which 19 retro-reflective markers were placed over the child's head, sternum, pelvis, acromion, and spinous processes of the spine. The placement of the spinal markers additionally allowed a detailed analysis of spinal segmental movements. Reliability of discrete parameters (ROM, min, max, angle at toe off and at initial contact) was assessed with the intraclass correlation coefficient (ICC); similarity of thorax and pelvis waveforms with the coefficient of multiple correlation (CMC).[4] Measurement errors were calculated for all parameters (SEM, σ).[5,6]

RESULTS

Acceptable within and between session reliability was found for the discrete parameters of the thorax, pelvis, shoulder line, angle of kyphosis and most spinal segmental angles, reflected by low SEM (<4°) and most ICCs >0.60. Only the angle of lordosis showed marked lower between session reliability. Waveform errors were good, with values below 4° within and between sessions. CMCs of the thorax and pelvis ranged from poor to very good, with highest values for movements in the frontal and transverse plane (CMC 0.62-0.93). Results also showed lowest within and between session reliability for head discrete parameters and waveforms (SEM and σ >5°), apart from total ROM and frontal movements (SEM and σ <4°).

DISCUSSION & CONCLUSIONS

This study supports the reliability of the proposed kinematic model to measure head and trunk movements during gait in children with spastic diplegia. Difficulties in standardization of head movements during gait warrant a careful interpretation of this segment's kinematic parameters. The reliability of a detailed spinal segmental movement analysis has not yet been reported in children with CP and overall results were satisfying. However, proper clinical implementation of the kinematic model requires a profound training of the assessor to assure accurate palpation of the spinal segmental markers.

REFERENCES

[1] Farmer. Disabil Rehabil 2003;25:807-16; [2] Forssberg. Curr Opin Neurobiol 1999;9:676-82; [3] Leardini et al. Clin Biomech (Bristol Avon) 2009;24:542-50; [4] Kadaba et al. J Orthop Res 1989;7:849-60; [5] Weir. J Strength Cond Res 2005;19:231-40; [6] Schwartz et al. Gait Posture 2004;20:196-203.

THE INFLUENCE OF HIP ABDUCTOR WEAKNESS ON FRONTAL PLANE KINEMATICS AND KINETICS IN PATIENTS WITH CEREBRAL PALSY

Britta K. Krautwurst[1], Sebastian I. Wolf[1], Daniel W. W. Heitzmann[1], Frank Braatz[1] and Thomas Dreher[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

Duchenne walking pattern is a common sequelae in various gait disorders and also found in cerebral palsy. Hip abductor weakness may result in pelvic obliquity and may be compensated by lateral shift of the trunk (trunk obliquity) to the ipsilateral side to maintain gait stability [1]. A reduction of abduction moment in Perthes patients with Duchenne gait was reported [2]. However, investigations addressing pelvis and trunk in frontal plane in CP patients are rare leaving unconsciousness on how to interpret these parameters. We investigated the correlation between hip abductor strength and frontal plane kinematics in CP patients. Furthermore hip abduction moment in these patients was evaluated.

PATIENTS/MATERIALS and METHODS

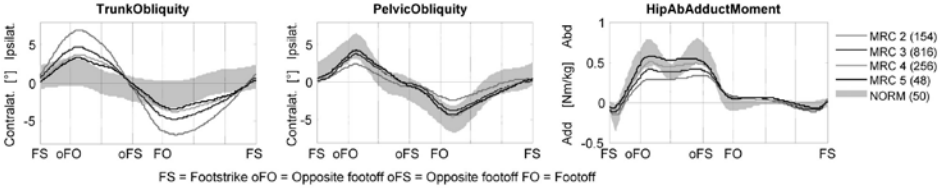
653 ambulatory (GMFCS I-II) patients (1306 limbs) with diplegic CP (mean age: 16 y) and 25 healthy controls were selected from our gaitlab database, who underwent a standardized three-dimensional gait analysis and a clinical examination including hip abductor strength testing (MRC-scale) between 1996 and 2012 and included in the study. Exclusion criteria were previous orthopedic surgery on the lower extremities. Selected frontal plane kinematic and kinetic parameters were statistically analyzed using unpaired t-tests and were correlated with hip abductor strength (MRC).

RESULTS

With weaker hip abductors significant more trunk obliquity, less pelvic obliquity and significant less abduction-moment was found (t-test: significant difference to the next higher MRC level). The results are summarized in Table and Figure 1.

	TrunkObliquity [°]	Pelvic Obliquity [°]	Hip AbAdduct [°]	AbAdductMoment [Nm/kg]	AbAdductPower [W/kg]	Glumed [%]
MRC2	7.76 **	4.46	7.44	0.54 **	0.45	286.69
MRC3	5.31 **	4.81	6.83	0.62 **	0.42	271.83
MRC4	4.38	5.14	6.76	0.69	0.4	281.46
MRC5	4.27 **	5.19	6.16	0.73	0.45 *	281.7
Norm	1.75	5.02	7.5	0.74	0.54	296.32

Table 1: Maximal value (0 – 100% gait cycle). * level of significance p<0.05; ** level of significance p<0.01



FS = Footstrike oFO = Opposite footoff oFS = Opposite footoff FO = Footoff

Figure 1: Frontal plane kinematics and kinetics for selected parameters - Mean MRC - groups (number of legs)

DISCUSSION & CONCLUSIONS

The results of this study prove that weak hip abductors in CP patients are accompanied by increased trunk tilt to the ispilateral side, while pelvic position is maintained by this compensatory mechanism. This indicate that a stabile pelvic position is of superior importance for CP patients compared to trunk position. The magnitude of trunk obliquity correlates with abductor weakness. In patients with MRC 2 compensatory trunk obliquity is not able to stabilize the pelvis anymore and frontal pelvic kinematics significantly vary from norm during loading response. It is important to consider frontal trunk kinematics when planning surgery since it represents one major indicator for hip abduction and pelvic stability.

REFERENCES

[1] Metaxiotis D. et al. (2000) Gait Posture 11: 86-91.

[2] Westhoff B et al. (2006) Gait Posture 24: 196-202.

GAIT ANALYSIS IN CHILDREN WITH HEMIPLEGIA AND ROBOTIC ASSISTED TREADMILL TRAINING

LORENA A LLORENTE[1], SERGIO M REYES[2] and VICTOR M BRIKISAK[3]

[1]TELETON, MEDICAL, CONCEPCION, CHILE
[2]TELETON, INFORMATIC, CONCEPCION, CHILE
[3]TELETON, KINESIOLOGY, CONCEPCION, CHILE

INTRODUCTION

There is evidence that locomotor therapy for regaining walking capacity using the principle of enhancing neuroplasticity by task-specific training is effective in the rehabilitation process of patients with central gait disorders. Body weight –supported treadmill therapy is used in adult and in pediatric rehabilitation to improve walking function in a task specific manner.

The gait analysis is an objective system to determine the changes in the walking performance after any treatment in rehabilitation.

However, there is not much research that included the Gait Analysis to measure the functional changes after Assisted Treadmill Therapy.

The aim of the study was to quantify with Gait Analysis the effect of Robotic Assisted Treadmill Therapy in some of the main gait parameters of Hemiplegic children.

PATIENTS/MATERIALS and METHODS

20 children (age mean 6 years + 1.2, 14 males and 6 females) were selected with diagnosis of Hemiplegia (Cerebral Palsy), Gross Motor Functional Classification System I and II, without previous treatments, for at least 3 months. They are patients of the Rehabilitation Institute Teleton of Concepción City in Chile.

The patients were treated in 18 sessions of 30 minutes each; walking speed was 1.3 Km/h with 60% body weight support.

Everyone was controlled by Gait Analysis (BTS, smartclinic system) before and after of Robotic Assisted Therapy (Hocoma, pediatric Lokomat).

In the Gait Analysis report, made one week before and one week after therapy; contra lateral single support, cadence, ipsilateral step length, contra lateral step length, step width, velocity and foot dorsal flexion peak in swing were considered.

Those data were averaged and statistical test was performed (wilcoxon test)

RESULTS

It was found that contra lateral single support improved in 2.2 %.The peak of foot dorsal flexion in swing was increased in 7.7 degrades, cadence improved in 21.7 step/min. and velocity improved in 0.2 m/s.

The change of the last 3 parameters was statistically significant (wilcoxon test).

DISCUSSION & CONCLUSIONS

The Robotic Assisted Therapy could be a beneficial treatment in the gait rehabilitation for children with diagnosis of Hemiplegia (CP), GMFCS I and II.

Those children improved their gait, probably, because were strengthened the ankle dorsal flexion muscles, reeducation motor engram was performed or improved their propioception.

REFERENCES

Robotic-assisted treadmill therapy improves walking and standing performance in children and adolescents with Cerebral Palsy. I.Borggraefe, J. S. Schaefer, M.Klauber.

SIX MINUTE WALK DISTANCE IN CHILDREN WITH CEREBRAL PALSY AND IN TYPICALLY DEVELOPING CHILDREN

Diarmaid Fitzgerald[1], Claire Hickey[2], Damien Kiernan[1], Eamonn Delahunt[2], Michael Walsh[1] and Timothy O'Brien[1]

[1]Central Remedial Clinic, Gait Laboratory, Dublin , Ireland
[2]University College Dublin , School of Public Health, Physiotherapy and Population Science, Dublin , Ireland

INTRODUCTION

The six minute walk test is used in children with cerebral palsy to quantify functional ability [1] and as an outcome measure to assess changes in ambulatory status over time or prior to and following specific treatment interventions. The aim of this research was to assess six-minute walking distance (6MWD) in children with cerebral palsy (CP) and in typically developing (TD) children.

PATIENTS/MATERIALS and METHODS

6MWD values for children with CP were taken from a database of patients referred to a gait analysis laboratory. TD children aged 4-17 were assessed prospectively using the same standardised protocol that was used to assess participants with CP. For analysis, participants with CP were subcategorised based on topographical diagnostic subtype (hemiplegic or diplegic) and Gross Motor Function Classification System (GMFCS) level.

RESULTS

Mean 6MWD was 535m (SD = 9.2) for TD participants (n = 73) and 382m (SD = 8.7) for participants with CP (n = 129). Results of a pair-wise comparison showed significant differences between 6MWD values of TD participants and across CP participants of all subcategories. Differences were seen across subcategories of CP participants with hemiplegic participants of GMFCS level I performing the longest distances (mean= 430m, SD = 12.6) and diplegic participants of GMFCS level III performing significantly shorter distances (mean=427m, SD=13) than any other subcategory.

DISCUSSION & CONCLUSIONS

A range of normative values for TD children and children with CP (GMFCS I-III) was established using a standardised protocol which can be used to quantify functional capacities of children with CP.

REFERENCES

[1] Maher CA, Williams MT, Olds TS. The six-minute walk test for children with cerebral palsy. International Journal of Rehabilitation Research, 2008, Jun;31(2):185-8.

EFFECT OF THE BENEFOOT WALKER ON PLANTAR PRESSURE DURING WALKING IN APPARENTLY HEALTHY PEOPLE

Ambreen Chohan[1], Kwadwo O Appiah-Kubi[2], Robert Van Deursen[3] and Dhaher Alanzi[4]

[1]School of Sport, Tourism & the Outdoors, University of Central Lancashire, Allied Health Research Unit, Preston, United Kingdom
[2]School of Allied Health Sciences, College of Health Sciences, University of Ghana, Physiotherapy, Accra, Ghana
[3]School of Healthcare Studies, Cardiff University, Physiotherapy, Cardiff, United Kingdom
[4]King Faisal Specialist Hospital, Physiotherapy, Riyadh, Kingdom of Saudi Arabia

INTRODUCTION

The development of diabetic foot ulcers is associated with excessive plantar pressure. The central goal of any treatment regime designed to heal these ulcers is the effective reduction of this excessive pressure. The use of an orthosis such as the Benefoot walker (BW) is a preferred non-surgical method for plantar pressure reduction. This study therefore investigated the difference in plantar pressure between the BW, compared to a control shoe (CS) during gait in apparently healthy people.

PATIENTS/MATERIALS and METHODS

Twenty-one apparently healthy volunteers (8 Males, 13 Females; Mean age 49.7±7.0 years) participated in the study.The mean height and weight of the participants was 1.67±0.1m and 75.9±18.2kg respectively. A consecutive sampling technique was used to recruit participants via local social groups, institutions and societies. Participants had no history of neurological, respiratory, musculoskeletal back or lower limb pathology, or any low back pain in the 12 months preceding the study.A crossover design was employed to study the differences between the BW and CS. Participants were asked to walk 10 meters in a pair of CS and then in a left CS with the BW on the right foot. The pedar-x (Novel gmbh, Germany) in-shoe pressure measurement system was used to measure plantar pressures at six sites (the heel, mid-foot, lateral metatarsal, medial metatarsal, hallux and the small toes) using insoles inside the footwear during testing. Descriptive statistics were used to analyse demographic data. Within subject analysis of mean peak plantar pressures (MPPPs) was compared between the CS and the BW, using the paired student t-test (SPSS v.17). The significance level was set to $p \leq 0.05$.

RESULTS

The MPPP of the CS trial yielded similar results for both feet, for all respective plantar sites ($p>0.05$). The BW however significantly reduced overall plantar pressure ($p= 0.002$) when compared to a CS on the same side. With the exception of the heel, the remaining 5 plantar pressure sites analysed showed that the plantar pressures in the right CS were higher than when walking with the BW on the right ($p< 0.05$). The most reduced plantar pressures occurred at the medial metatarsals (129.38±67.93 kPa; $p<0.05$), followed by the hallux (128.58±135.32 kPa; $p<0.001$) and lateral metatarsals (122.14±53.35kPa; $p< 0.001$), with the mid-foot (7.89±44.29kPa; $p= 0.424$) being the least.

DISCUSSION & CONCLUSIONS

Compared to the CS, the BW reduced mean plantar pressure by 18.9% when comparing the same side. The BW was effective in reducing plantar pressure significantly at all plantar sites except for the heel and mid-foot. The inability of the walker to reduce sufficient heel pressure would indicate that clinicians should be cautious when prescribing such orthoses to those with higher plantar pressures in this area. Further studies are required using neuropathic patients to determine the clinical benefits of the BW.

REFERENCES

Ha Van G, Siney H, Hartmann-Heurtier et al. 2003. Nonremovable, Windowed, Fiberglass Cast Boot in the Treatment of Diabetic Plantar ulcers. Diabetes Care 26:2848–2852.

Van Schie CH, Rowell S, Knowles A and Boulton AJ. 2003. The effect of the Scotchcast Boot and the Aircast Device on foot pressures of the contralateral foot. Wounds 15(9):289–293.

PEDOBAROGRAPHIC RESULTS IN CHILDREN WITH INSOLE TREATMENT

Susanne Lebek[1], David Wohlrab[2], Matti Panian[3], Natalia Gutteck[2] and Karl-Stefan Delank[2]

[1]University of Halle, Orthopaedic Department, Halle, Germany
[2]University of Halle, Orthopaedic Department , Halle, Germany
[3]Orthopaedic Dept., University, Gait Laboratory, Halle, Germany

INTRODUCTION

So called proprioceptive insoles are supposed to improve the foot shape as well as to modulate plantar surface sensibility thereby influencing posture and coordination.

We evaluated the pedobarographic results of 5 to 12 year old children to prove this effect and the usefulness of pedobarography in children.

PATIENTS/MATERIALS and METHODS

We assessed 15 children (6 girls, 9 boys) with a mean age of 8.4 years (SD 2.2 years), who wore proprioceptive insoles (insole group) prescribed by their physician for at least one year (mean 3.2 years, 1 to 6 years). Their pedobarographic results as well as their results of some coordination tests [1] were compared to an age- and BMI- matched group (control group) of 30 children (16 girls, 14 boys; mean age 8.4 years, SD 1.9 years). The mean BMI was 17.9 kg/m^2 (SD 3.4). The pedobarography was performed with the Emed System, Novel, Germany. SPSS was used for statistical analysis (Mann Whitney Test, $p < 0.05$).

RESULTS

There were found no statistical differences (table 1).

Table 1 Results of the coordination tests, the posturograms and the arch indices

	n	Coordination velocity	Coordination precision	Arch index	n	Posturogram (in cm^2)
Insole group	15	37.4 (SD 16.4)	2.3 (SD 2.9)	0.19 (SD 0.065)	12	55.4 (SD 53)
Control group	30	42.6 (SD 16.2)	1.3 (SD 2.2)	0.20 (SD 0.067)	14	28.4 (SD 24.6)
p		0.252	0.518	0.847		0.068

DISCUSSION & CONCLUSIONS

An effect on the arch index or the coordination caused by special proprioceptive insoles could not be found in our controlled study. It cannot be determined whether the children in the insole group improved and showed normal results caused by wearing the insoles. We think that pedobarography is a useful tool to evaluate children's feet dynamically in order to get more knowledge about the natural history of feet development [2] thereby aiming at the optimal time for conservative and surgical interventions.

REFERENCES

[1] Prätorius B, Milani TL. Kinder-Koordinationstests. Diss., 2007.

[2] Bosch K, Gerß J, Rosenbaum D Development of healthy children's feet-Nine year results of longitudinal investigation of plantar loading patterns. Gait & Posture, 2010.

A CLINICAL TRIAL OF THE WEARABLE ROBOT SUIT (HAL)

Tatsuo Kobayashi[1], Ryosuke Sanpei[1], Kenichi Kaida[2] and Masanori Fujita[3]

[1]National Defense Medical College, Rehabilitation Medicine, Tokorozawa, Japan
[2]National Defense Medical College, Neurology, Tokorozawa, Japan
[3]National Defense Medical College Research, Environmental Medicine, Tokorozawa, Japan

INTRODUCTION

The Hybrid Assistive Limb (HAL) developed as a wearable robot suit for the handicapped is a hopeful welfare instrument in Japan, which is threatened to be an ultra-aging society in the near future. The present report is about the volunteers with disfunction of lower limbs, who have tried out HAL.

PATIENTS/MATERIALS and METHODS

The volunteers are 3 patients with disfunction of lower limbs; the first is with traumatic incomplete lumbar spinal cord injury, the second with incomplete paraplegia after surgery for dissecting aneurysm, the last with Kennedy Alter Sung disease. Each patient had standing and walking training twice a week, 10 times in all, wearing HAL. Their joint movability, muscle strength, time of 10-meter walk, and Time Up and Go test (TUG) results before and after the trial have been evaluated.

RESULTS

The first volunteer with traumatic incomplete lumbar spinal cord injury can walk on 2 Lofstrand crutches and a long leg brace. After the trial, his time of 10-meter walk reduced from 10.2 seconds to 7.5 seconds and his TUG result from 13.4 seconds to 8.8 seconds. The assist of a short leg brace was needed because HAL does not have corrective function for pes equinovarus contracture.

The second with incomplete paraplegia after surgery for dissecting aneurysm is incapable of standing or walking. HAL has enabled him to stand and walk on 2 side canes, though no improvement has been found in his joint movability, muscle strength, and activity function.

The last with Kennedy Alter Sung disease has difficulty in rising from a chair, but can walk on T-cane. By wearing HAL, he became able to rise from a chair and to walk without T-cane.
Both the second and the last patients needed someone's assistance to keep his balance in standing and walking.

DISCUSSION & CONCLUSIONS

The first case has showed therapeutic effect of wearing HAL and the second and the last showed function improvements while wearing HAL. The current problems about clinical use of HAL found through this trial are its lacking in corrective function for deformation and in controlling function for standing balance.

REFERENCES

MECHANICAL PROPERTIES OF A SPRING-HINGED FLOOR REACTION ORTHOSIS

Yvette L Kerkum[1], Merel A Brehm[1], Annemieke I Buizer[1], Josien C Van den Noort[1] and Jaap Harlaar[1]

[1]VU University Medical Center, Rehabilitation Medicine, Amsterdam , The Netherlands

INTRODUCTION

For children with cerebral palsy (CP) whose gait pattern is characterized by excessive knee flexion in midstance, a Floor Reaction Orthosis (FRO) is commonly prescribed. FROs are very stiff and aim to counteract excessive knee flexion in midstance, by shifting the ground reaction force anteriorly. Although an FRO is effective in this respect (1), it impedes plantar flexion in preswing, thereby obstructing push-off power. A spring-like FRO could potentially be more beneficial, since it can store energy at the beginning of the stance phase, being returned in preswing, thereby creating ankle push-off power. Literature shows that energy cost of walking with a typical spring-like Ankle-Foot Orthosis can be minimized by selecting an optimal stiffness (2). Recently, a new type of hinge with adjustable springs was designed, which can be integrated into an FRO. However, exact knowledge of the mechanical properties of the hinge is lacking. This study aims to quantify the mechanical properties of this new hinge build within an FRO.

PATIENTS/MATERIALS and METHODS

One test FRO with an integrated 14mm Neuro Swing® ankle joint (Fior & Gentz, Germany) was constructed. We used five springs within the hinge, with different stiffness's. The spring's mechanical properties were measured with BRUCE (3). Each spring was fully compressed and released slowly (i.e. a few seconds for the whole range of motion (ROM)) 3 times, while the hinge angle and the exerted net moment were continuously measured (3). ROM [deg] (i.e. elastic range), stiffness [Nm/deg] (i.e. slope of the linear fit of the relation between angle and net joint moment in the ROM), threshold [Nm] (i.e. exerted moment at the start of ROM), and hysteresis [%E_{STOR}] (i.e. storage (E_{STOR}) minus release (E_{RLS}) of energy) were averaged for each spring. E_{STOR} was defined as the surface underneath the compression phase (upper line) and E_{RLS} as the surface underneath the release phase (lower line).

RESULTS

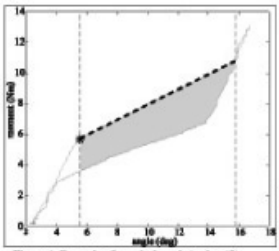


Figure 1. Example of a typical result (spring #3)

Table 1. Mechanical properties of the five springs integrated into the 14 mm Neuro Swing® system ankle joint

Spring#	ROM (deg)	Stiffness (Nm/deg)	Threshold (Nm)	Hysteresis (%E_{STOR})
1	12.1	0.01	1.4	28.5
2	13.9	0.22	3.1	27.9
3	10.2	0.51	5.7	26.4
4	11.7	0.62	8.1	22.8
5	6.2	1.61	20.6	14.0

Figure 1 represents a typical result of a measurement. The area between the vertical lines indicates the ROM. Furthermore, the linear fit (bold line), threshold (*), and hysteresis (shaded area) are indicated.

DISCUSSION & CONCLUSIONS

Our results indicate that the five springs seem to be useful in optimizing orthoses with respect to energy cost of walking in children with CP. Hysteresis, probably mainly caused by friction of the spring in the shaft of the hinge, is present in all springs, resulting in a loss of energy that potentially could be used for ankle push-off. Nevertheless, FROs with integrated springs might still be more beneficial compared to conventional FROs, in which no energy can be stored at all. However, it remains unknown whether the stiffness of the springs is sufficient to counteract knee flexion in stance. This will be subject of further research to investigate the effects of the mechanical properties of the springs on gait in CP.

REFERENCES

(1)Rogozinski et al.(2009) *J Bone Joint Surg Am,*91:2440-7; (2)Bregman et al.(2011) *Jour of Neurorehabil Neur Repair,* submitted; (3)Bregman et al.(2009) *Gait Posture,*30(2): 144-9

AN ELECTROMYOGRAPHIC STUDY OF PATIENTS WITH MASTICATORY MUSCLE DISORDERS: A RANDOMOZED CONTROLLED CLINICAL TRIAL

Daniela Aparecida Biasotto-Gonzalez[1], Tabajara de Oliveira Gonzalez[2], Fabiano Politti[2], Daniel Ventura de Andrade[1], Yasmin El Hage[1], Cid André Fidelis de Paula Gomes[2], Dowglas Fernando Magalhães de Sousa[1], Graziela F Aparecido[1], Carolina M Herpich[1], Cesar Ferreira Amorin[3] and Fausto Berzin[4]

[1]July Nine University , Master of Rehabilitation Sciences, São Paulo, Brazil
[2]July Nine University , Physiotherapy, São Paulo, Brazil
[3]Cidade de São Paulo University , Physiotherapy Master´s Program, São Paulo, Brazil
[4]College of Dentistry, State University of Campinas, Morphology, Piracicaba, Brazil

INTRODUCTION

The most common etiologic agent regarding the myogenic TMD is the muscular hyperactivity.This hyperactivity can contribute to internal disarrangements of the TMJ. Several treatment options are proposed to muscular disorder[1] .Nevertheless, the intent of this project is to assess the physiotherapeutic and odontologic approach of massage therapy and occlusal splint in miogenic TMD volunteers through the analysis of the electromyographic trace, comparing pre and post therapeutic bilaterally behavior of the masseter muscle and the anterior portion of the temporal muscle during the bilateral masticatory activity.

PATIENTS/MATERIALS and METHODS

Male and female individuals aging between 18 and 40 years old were assessed. All subjects were submitted to the EMG assessment. The volunteers were divided in four groups. *GroupI: 12* young with signs and/or symptoms of myogenic TMD. They were submitted massage therapy. *Group*II: 12 young with signs and/or symptoms of myogenic TMD. They were submitted occlusal splint. GroupIII: 12 young with signs and/or symptoms of myogenic TMD. They were submitted massage therapy and occlusal splint. GroupIV:12 subjects with normo-occlusion and no history of temporomandibular disorder. They were submitted to the EMG exams, but not to the physiotherapeutic and odontologic treatment. Important to mention that only partial results will be presented in this study.

RESULTS

Considering the data obtained and the statistical analysis performed in each studied groups, and noticed that with the techniques applied on the Groups I, II, III and IV, no significant result of EMG activity of all the muscles in study was collected. But, the results point out the difference (p=0,0026) between the AVS scores, which was taken before and after the treatment (analyzed by the ANOVA statistical test).

DISCUSSION & CONCLUSIONS

There was a significant decrease in pain Group I, after Group III, after group II and Group IV don't have difference. The data collected in this study demonstrated that the massage therapy was efficient in decreasing the pain[2]. Even though it is not possible to draw a comparison with the literature that deals with the effect of massage therapy in patients with bruxism because this parcial results. The physiotherapeutic treatment (massage) and odontologic treatment (occlusal splint) and both treatment together can reduce and eliminate pain. However, the physiotherapeutic and both treatment together can reduce and eliminate pain more.

REFERENCES

1 - Biasotto-Gonzalez DA, Bérzin F. **Electromyographic study of patientswith masticatory muscles disorders, physiotherapeutic treatment (massage)** Braz J Oral Sci. July/September 2004 - Vol. 3 - Number 10. p 516-521

2 - Capellini VK, Souza GS, Faria CRS. **Massage Therapy in the management of myogenic TMD.** Journal of Applied Oral Science. 2006 Fev;14(1)

APPLICATION OF NEUROMUSCULAR ELECTRICAL STIMULATION IN THE MANAGEMENT OF HIP AND KNEE EXTENSOR WEAKNESS IN CHILDREN WITH CEREBRAL PALSY: A PILOT STUDY

Neil J Postans[1] and Andrew P Roberts[1]

[1]RJAH Orthopaedic Hospital NHS Foundation Trust, ORLAU, Oswestry, UK

INTRODUCTION

Weakness of the hip and knee extensors in children with cerebral palsy (CP) presents a major challenge during post surgical rehabilitation and remains a major obstacle to mobility. Neuromuscular electrical stimulation (NMES) can increase strength[1], but studies in CP have been equivocal[2]. Lack of selective control may prevent CP children from utilizing increases in strength effectively. Electromyography (EMG) triggering requires practice of volitional control which may enhance motor learning[3]. This pilot study investigated the effects of EMG triggered NMES of the gluteal and quadriceps muscle groups on strength and gait kinematics in six CP children.

PATIENTS/MATERIALS and METHODS

Six subjects were recruited; 4 female, 2 male, mean age 10 yrs 8 months (SD 2 yrs 6 months). Inclusion criteria were; Aged 7 to 14 years, diagnosis of spastic diplegic cerebral palsy, crouch gait pattern, no orthopaedic surgery in the last 12 months or botox injections in the last 6 months. Subjects acted as their own controls in an ABA study design, with baseline, treatment and follow up periods of 12 weeks. During treatment, subjects used NMES for up to 30 minutes per day. EMG triggering required subjects to initiate hip and knee extension prior to the onset of NMES, and an integrated computer game provided biofeedback. Stimulation intensity was set to produce as strong a contraction as was comfortable. During baseline and follow up, patients continued with regular therapy. Dynamometry and 3D gait analysis were performed at the start and end of each phase. The NMES devices logged compliance data.

RESULTS

There were no significant differences in strength, or in minimum knee and hip flexion during gait, between baseline, treatment and follow up. When considered individually, there were no clear trends in the strength measurements for any of the subjects. There was a trend towards improvement in hip and knee extension following treatment for one subject, which was not maintained at follow up. One subject showed some deterioration in knee flexion throughout the duration of the study. Average treatment compliance was 31%.

DISCUSSION & CONCLUSIONS

Compliance with the treatment protocol was low (18%) for the subject who showed some improvement in gait pattern, indicating that this result was likely to be due to other variables. This was not replicated amongst other subjects for whom compliance was better. The deterioration in gait for one subject may have been related to a growth spurt during the study period. None of the subjects' families reported any significant difficulties in using the equipment, however, the overall compliance data suggest daily home based treatment using this protocol may not be realistic. There are still challenges to overcome if the potential strengthening effects of NMES are to be replicated in CP children.

REFERENCES

[1] Avramidis K et al (2003) Effectiveness of electric stimulation of the vastus medialis muscle in the rehabilitation of patients after total knee arthroplasty. *Arch Phys Med Rehabil*. 2003 Dec;84(12):1850-3.

[2] Kerr C et al (2006) Electrical stimulation in cerebral palsy: a randomized controlled trial. *Dev Med Child Neurol* 48(11):870-876.

[3] Wulf G (2007) Self-controlled practice enhances motor learning: implications for physiotherapy. *Physiotherapy* 93(2):96-101.

CHANGES IN SURFACE EMG PATTERNS IN CHILDREN WITH CEREBRAL PALSY DURING ROBOTIC GAIT TRAINING. COMPARISON TO TREADMILL TRAINING.

Marcin Bonikowski[1] and Patrycja Mrozek[1]

[1]Mazovian Neurorehabilitation and Psychiatry Center, Rehab. Department, Movement Analysis Lab., Warsaw, Poland

INTRODUCTION

Robotic rehabilitation equipment allows for intensive, goal focused training that does not tire physiotherapists. Latest evidence shows, that such training improves mobility in children with Cerebral Palsy (CP) (1).

The aim of the research is to check if training with a robotic driven gait orthosis (DGO) Lokomat changes muscle activation in comparison to exercise on a treadmill, and what other training parameters can influence it.

PATIENTS/MATERIALS and METHODS

Ten CP children, GMFCS level 2 or 3, attended identical training / diagnostic sessions on a robotic driven gait orthosis (DGO) Lokomat (Hocoma). Examination was conducted after a 15-minutes training on DGO, during which both comfortable and maximum speed were determined. Next an EMG activity assessment was conducted during training on the DGO and on a treadmill with a bodyweight-support Levi system. The examination was conducted at comfortable and maximum speeds, with 50% and 100% leading force, with 30% bodyweight-support or without it. Sagittal video recordings of gait were made, together with simultaneous surface electromyography recordings of the Rectus Femoris m. (RF), Semitendinosis m.(ST) using the ME6000 system with Megawin software (Mega Electronics Ltd). 8 trials were conducted on the DGO and 4 on a a treadmill in different combinations of bodyweight-support and leading force. In order to calculate average levels of EMG, SD, min., max., surface and median, in each of the trials 20 steps were taken from a 30 second recording and averaged with RMS.

RESULTS

A significant ($p<0,05$) increase EMG activity was observed during training on a treadmill in comparison to that on the Lokomat in all of the trials. Moreover, increase of average EMG levels were also observed with smaller bodyweight-support and leading force.

DISCUSSION & CONCLUSIONS

These preliminary results show, that the Lokomat changes muscle activity in comparison to walking on a treadmill more than just using bodyweight-support. Lower levels of muscle activation and less physical effort allow for long trainings with CP children, GMFCS levels II, III and even IV for whom the possibilities of gait improvement are greatly limited. This is probably a factor influencing the treatment.

REFERENCES

1. Borggraefe I, at. al Eur J Phys Rehabil Med. 2010

DEVELOPMENT OF MUSCLE TONE AND ELECTROMYGRAPHIC PATTERNS AFTER MUSCLE-TENDON SURGERY IN CHILDREN WITH SPASTIC DIPLEGIA

Thomas Dreher[1], Reinald Brunner[2], Dóra Vegvari[1], Daniel Heitzmann[1], Simone Gantz[1], Michael W Maier[1], Frank Braatz [1] and Sebastian I. Wolf[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany
[2]University Children's Hospital Basel, Pediatric Orthopaedic Department, Basel, Switzerland

INTRODUCTION

During multilevel surgery, muscle-tendon lengthening (MTL) is commonly carried out to correct deformities. However, it is unclear if MTL also modifies muscle tone by reducing tension on the neuro-muscular spindle and if pathologic activation patterns are changed as an effect of the biomechanical changes. Since investigations addressing muscle tone after MTL are limited [1], we evaluated the effects of MTL on muscle tone and activation pattern at short- and mid-term.

PATIENTS/MATERIALS and METHODS

Forty-two children with spastic diplegia who were treated by multilevel surgery including MTL of the hamstrings and calf muscles underwent standardized clinical examination including MAS (modified Ashworth scale), dynamic EMG and 3D gait analysis before (E0), one (E1) and three years (E2) after MTL. For muscle activation patterns the norm-distance of dynamic EMG data was analyzed. ANOVA was used ($p<0.05$).

RESULTS

Range of motion and joint alignment in clinical examination were found to be significantly improved at E1. However, deterioration of these parameters was noted at E2. MAS was significantly reduced at E1 but showed an increase between E1 and E2 (Fig. 1). Joint kinematics were found significantly closer to reference data at E1 but deteriorated until E2. However, the EMG patterns of the surgically addressed biarticular muscles (Fig.2) were not found to be changed significantly in either follow-up.

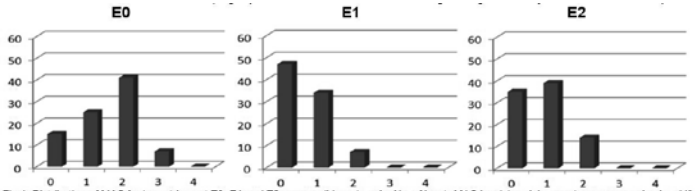


Fig.1: Distribution of MAS for hamstrings at E0, E1 and E2 among all legs (y-axis=No. of legs). MAS level 1 and 1+ are shown summarized as "1".

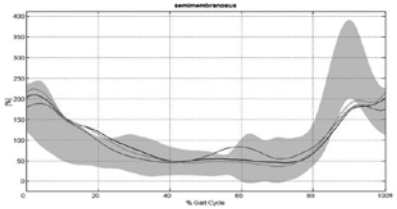


Fig.2: Mean EMG data of semimembranosus muscle for all patients are shown. The EMG amplitudes were normalized to the mean value for each muscle of each step and subject respectively. Graphs are visualized for all examinations: preoperative (red line), 1 year post- (blue line) and 3 years (pink line) post intervention. In all graphs the reference data including obtained by an age-matched group of 25 norm subjects is represented by the grey area (including 1 standard deviation).

DISCUSSION & CONCLUSIONS

Despite the influence of MTS on biomechanics and physiology (tone reduction and improvements of joint mobility and gait pattern) MTS does not change abnormal patterns of muscle activation counter-intuitively. The findings of this study are of major clinical importance. Recurrence of increased muslce tone and deterioration of gait analysis as well as clinical parameters between E1 and E2 may be attributed to these persistent pathological activation patterns.

REFERENCES

[1] Vlachou M et al., Acta Orthop Belg. 2009;75:808-14.

DIFFERENCES BETWEEN CHILDREN AND ADULTS IN UPPER LIMB MOTOR CONTROL DURING THE EXECUTION OF TYPICAL ROBOTIC REHABILITATION TASKS.

Alessandra Pacilli[1, 2], Marco Germanotta[1, 2], Stefano Rossi[1, 2], Maurizio Petrarca[2], Enrico Castelli[2], Paolo Cappa[1, 2]

[1]"Sapienza" - University of Rome, Department of Mechanical and Aerospace Engineering, Rome, Italy
[2]"Bambino Gesù" Children's Hospital, IRCCS, Movement Analysis and Robotic Laboratory (MARLab) - Pediatric Neuro-Rehabilitation Division, Rome, Italy

INTRODUCTION

Robot for rehabilitation treatment are not only employed for the treatment and performance evaluation for stroke survivors, but also to assess in healthy subjects their adaptability to dynamic fields. In this context, few studies have investigated the age-related modifications of motor control strategies [1]. Although motor control differences between adults and children have been observed [2], in our knowledge no studies have quantified them during rehabilitative robot tasks. In order to achieve this goal, we decided to comparatively examine upper limb kinematics during circle drawing tasks in healthy adults and children; that choice is justified because the previously indicated task: (i) is widely used for patients evaluation, and (ii) it requires coordination of both the shoulder and elbow joints.

PATIENTS/MATERIALS and METHODS

Eight healthy, right children (age:8.0±1.0 years) and eight healthy, right adults (age:24.5±1.2 years) were asked to track 8 ClockWise (CW) and 8 CounterClockWise (CCW) circles (radius: 8 cm) in the horizontal workspace, with the InMotion Arm Robot device. An optoelectronic system (Vicon 512) was used to acquire kinematics for the upper limb and the trunk. As smoothness indicator, we used the Speed Metric (SM) [3] calculated as the mean of the speed divided by the peak speed; instead, the correlation between the elbow flexion angle and the abd-adduction shoulder angle, called Joint Correlation (JC) [4], was used to explore the synergies of the entire upper limb.

RESULTS

As shown in Fig.1, the mean JC is not statistically significant different ($p>0.05$) between adults and children, both in CW and CCW trials, while the SM index is always higher ($p<0.05$) for the adults (SMCCW=0.59±0.06; SMCW=0.63±0.10) than for children (SMCCW=0.40±0.06; SMCW=0.45±0.06)

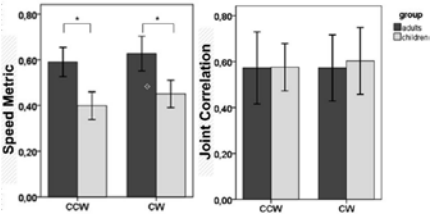


Figure 1 – Mean SM (left) and mean JC (right) for adults and children during CW and CCW trials.

DISCUSSION & CONCLUSIONS

The motor synergy of the upper limb is completely developed in children aged 8.0±1.0, as results from the JC values; nevertheless, the lower values of the SM clearly show that children has not yet reached the typical young adults fine tuning of muscular movement.

REFERENCES

[1] Takahashi et al (2003), Journal of Neurophysiology
[2] Jansen-Osmann et al (2002), Experimental Brain Research
[3] Rohrer et al (2002), Journal of Neuroscience
[4] Dipietro et al (2007), Journal of Neurophysiology

MODIFICATION OF UPPER LIMB PERFORMANCE WITH AND WITHOUT VISUAL FEEDBACK IN A PATIENT WITH CEREBRAL PALSY: A CASE STUDY.

Marco Germanotta[1, 2], Alessandra Pacilli[1, 2], Stefano Rossi[1, 2], Maurizio Petrarca[2], Enrico Castelli[2], Paolo Cappa[1, 2]

[1]"Sapienza" University of Rome, Department of Mechanical and Aerospace Engineering, Rome, Italy
[2]"Bambino Gesù" Children's Hospital, IRCCS, Movement Analysis and Robotic Laboratory (MARLab) - Pediatric Neuro-Rehabilitation Division, Rome, Italy

INTRODUCTION

Cerebral palsy (CP) is one of the most common childhood disorders, with an incidence of 2-2.5 per 1000 living births [1]. With respect to motor impairments, disturbances in proprioception has less studied [2]. However, it has been shown how activity limitations in children with CP are related not only with movement execution, but also with the planning of movement, which is strongly related to the proprioceptive system [3]. Therefore, this study aimed to compare motor performance of a hemiplegic child, in the presence and absence of visual feedback, with an age-matched healthy group.

PATIENTS/MATERIALS and METHODS

Five healthy subjects (8±2 years old) and one patient with cerebral palsy (8 years old) were involved in the present study. They were asked to perform circle drawing tasks (8 cm diameter) with the planar robot InMotion Arm Robot (Interactive Motion Technologies, Inc., US). Specifically, they were asked to first draw three circles clockwise (CW) and three circles counterclockwise (CCW), while visual feedback was provided on a monitor (eyes open condition, EO); then, they were asked to perform the same movements blindfolded (eyes closed condition, EC). Performance was evaluated by means of two indexes: the ratio between the axis of the ellipse best fitting the hand path; and the ratio between the area of the performed ellipse and the area of the displayed circle.

RESULTS

In Fig.1, the mean values of the two metrics (area ratio and axes ratio), with and without visual information, are reported for healthy subjects and the pathologic subject. Without visual feedback, axes ratio metric mean values are higher in the control group (>1) and smaller in the pathologic subject (<1). Otherwise, trend and mean values of axes ratio metric are similar in control group and in the child with CP, both in EO and EC. For both metrics, performance of the child with CP is worse in CCW than in CW direction. Healthy subjects, instead, seem to be not influenced by direction of movement.

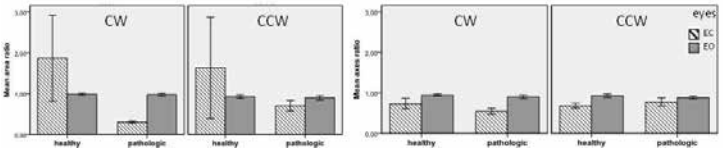


Fig. 1. Mean values and SDs of area ratio (left) and axes ratio (right).

DISCUSSION & CONCLUSIONS

The area ratio index suggests that the child with CP perceives the space, in absence of a visual feedback, in a different way, compared with healthy subjects. In fact, the control group seems to underestimate it, while child with CP seems to overestimate it. The disease, however, does not appear to affect the ability to perform the requested task in EC, as shown by axes ratio index. Finally, the difference of both metrics in CW and CCW might be explained by an effect of lesion side on the planning of the movement.

REFERENCES

[1] Lin (2003), J Neurol Neurosurg Psychiatry
[2] D. J. Goble, et al (2009), International Journal of Rehabilitation Research
[3] B. Steenbergen et al (2006), Developmental Medicine and Child Neurology

THE "ARM POSTURE SCORE" FOR ASSESSMENT OF ARM SWING DURING GAIT: EVALUATION OF ADDITIONAL ROTATIONAL COMPONENTS AND DIFFERENT GAIT SPEEDS

Gunilla E Frykberg[1], Gudrun Johansson[1], Helena Grip[1], Jonas Selling[1] and Charlotte Häger[1]

[1]Umeå University, Department of Community Medicine and Rehabilitation/Physiotherapy, Umeå, Sweden

INTRODUCTION

Traditionally, focus in 3D gait analysis has been on the lower extremities with considerable less attention paid to the role of the arms and their movements. The Arm Posture Score (APS) was recently presented for assessment of arm swing in children with cerebral palsy [1]. This index is calculated from four arm movement variables (shoulder flex/ext; shoulder abd/add; elbow flex/ext; wrist flex/ext), and will from now on here be referred to as APS_4. A potential limitation of this arm score is that it does not include any rotational movements. The aims of the present study were, in healthy adults, firstly to investigate the effect on APS_4 by adding two components of arm rotation (shoulder int/ext rot; forearm pro/sup), which results in an index referred to as APS_6, and secondly to determine the influence of gait speed on both APS_4 and APS_6.

PATIENTS/MATERIALS and METHODS

Twenty-five healthy subjects (14 women, mean age 64 yrs ± 13) have so far participated. Data collection was performed in a movement laboratory with 8 optoelectronic cameras (240 Hz, Oqus®, Qualisys, Gothenburg, Sweden) and 27 passive markers applied on anatomical landmarks and rigid clusters on the trunk and bilaterally to the upper extremities. The subjects walked 10m on a walkway at self-selected speed (mean 1.35m/s ± 0.15). A subgroup of eleven subjects (6 women, mean age 63 yrs ± 13) walked at a slow speed (paced by a metronome, 0.68 m/s ± 0.07) in addition to the self-selected speed. Six trials per subject were analysed. Calculations of gait variable scores (GVS, for each movement variable) and APS_4 were performed according to Riad et al [1] and in addition we calculated APS_6. The deviation of each movement variable from the value of the reference data, i.e. the whole group of participants, was calculated as the root mean square difference (RMSD) from normal. The APS score then equals the RMS-average of four or six GVS, respectively. The unit of APS is in degrees and a higher value implies a larger deviation from normal. The statistical analyses were performed with Wilcoxon signed rank tests and a level of $p<0.05$ was considered significant.

RESULTS

Preliminary results demonstrate significantly higher APS_6 values, as compared to APS_4, for both arms at self-selected walking speed ($p<0.001$). When walking at a slow speed, the deviation from normal revealed significantly higher APS_6 than APS_4 values for the dominant arm ($p= 0.006$), while there was no significant difference for the non-dominant arm ($p=0.05$). Both APS_4 and APS_6 showed significantly higher values regarding both arms, i.e. more deviating from normal, during slow walking as compared to the self-selected speed.

DISCUSSION & CONCLUSIONS

Adding two rotational arm components to the earlier presented APS [1] resulted in significantly higher values on most APS_6variables, i.e. APS_6 gives a higher value than APS_4. These results might imply that the two additional arm components provide relevant information of arm swing during gait in healthy subjects. A slower gait speed resulted in significantly higher APS_4 as well as APS_6 values indicating more deviant arm movements during slow walking. Thus, gait speed may need to be taken into account when quantifying arm swing during gait using 3D information. As this is an ongoing study where preliminary results are reported and merely in a small group of subjects there is a need for more data as well as a deeper scrutiny of the character of APS_4 and APS_6 for determination of its usefulness to describe arm movements during gait as well as to evaluate effects of intervention.

REFERENCES

[1] Riad J, Coleman S, Lundh D, Broström E. Gait Posture. 2011;33(1):48-53.

THE ARM POSTURE SCORE WITH ADDITIONAL ROTATIONAL COMPONENTS (APS6) APPLIED TO PERSONS WITH STROKE TO ASSESS ARM MOVEMENTS DURING GAIT

G M Johansson[1], G Elmgren Frykberg[1], J Selling[1], H Grip[1], E Weidenhielm Broström[2] and C Häger[1]

[1]Umeå University, Dept of Community Medicine and Rehabilitation; Physiotherapy, Umeå, Sweden
[2]the Karolinska Institute, Dept of Women's and Children's Health, Stockholm, Sweden

INTRODUCTION

Clinical assessments used in stroke rehabilitation often overlook arm movements during gait. However, three-dimensional (3-D) motion analysis has made it possible to provide comprehensive objective measures of such movements and recently the Arm Posture Score (APS) was presented as an index to quantify arm movements during walking in children with spastic hemiplegic cerebral palsy [Riad et al, 2011]. The APS was based on calculations including four arm movement variables (shoulder flexion/extension; shoulder abduction/adduction; elbow flexion/extension; wrist flexion/extension), from now on referred to as APS_4. This index has not been tested in a stroke population and further, a potential limitation of APS_4 may be that it does not include any rotational movements.The aims of our study were to investigate the applicability of APS_4 to persons with stroke compared to healthy controls and to investigate the effect on APS of adding two rotational components (shoulder internal/external rotation and forearm pronation/supination), from now on referred to as APS_6.

PATIENTS/MATERIALS and METHODS

So far 16 patients with stroke (9 men, 7 women, age 69 y $\pm$ 11 y) and 25 healthy controls (11 men, 14 women, age 64 y $\pm$ 13 y) have been assessed with an 8-camera 3-D motion capture system (240 Hz, Oqus®, Qualisys Gothenburg, Sweden). Reflective markers were placed on anatomical landmarks and clusters. Segments included the thorax, upper arms, forearms, and the hands. A 6 degree-of-freedom model was used: i.e. local coordinate systems of each segment were defined by markers on anatomical landmarks at the end points of each segment, and a set of 3-4 markers was used to track the movement of the segment. Adults were included who had a residual unilateral hemiparesis following an ischemic or hemorrhagic stroke at least 3 months post stroke and who were medically stable. They could voluntarily move the upper extremity against gravity, walk indoors without aids, and understand both verbal and written information. Participants walked 10 m at a self selected speed, 4-6 trials. The APS was based on kinematic data according to the mathematical construction of the Gait Profile Score (GPS) [Baker et al, 2009]. The deviation of each variable was calculated as the root mean square (RMS) difference from normal and the APS as the total deviation of these four and six variables, respectively. The APS is reported in degrees, and a higher value indicates a larger deviation from normal. The data from the left and right arm were analysed separately.

RESULTS

Preliminary analysis show significantly higher values of APS_4 and APS_6 for the paretic arm compared to the control group (non-dominant arm; $p=0.006$, $p=0.015$, respectively) indicating a pathological deviation from normal. No differences were found between the non-paretic arm and control group (dominant arm). The two additional rotational components increased the APS values significantly for the paretic and non-paretic arm in the stroke group ($p=0.049$, $p=0.001$, respectively) as well as in the control group (both arms; $p=0.000$). Both groups showed higher variability in the rotation variables compared to the four other variables.

DISCUSSION & CONCLUSIONS

The preliminary results suggest that the APS is a useful index to discriminate between impaired arm swings during gait for persons with stroke compared to healthy controls. The variability of shoulder and forearm rotation during arm swing needs to be further investigated before fully considering the additional value of APS_6 compared to APS_4.

REFERENCES

CHANGES IN GAIT KINEMATICS, ASYMMETRY AND BALANCE AFTER DEEP BRAIN STIMULATION (DBS-STN) SURGERY.

Michael E. Smpiliris[1], Pantelis Stathis[1], Stylianos Gatzonis[2], Efstathios J. Boviatsis[2], N. Darras[3], M. Tziomaki[3] and Damianos E. Sakas[2]

[1]Sismanoglion Hospital, Department of Neurology, Athens, Greece
[2]University of Athens, Evangelismos Hospital, Hellenic Centre for Neurosurgery Research H.C.N.R. "Petros Kokkalis Foundation", Department of Neurosurgery, Athens, Greece
[3]Hellenic Society for Disabled Children (ELEPAP), Gait & Motion Analysis Center, Athens, Greece

INTRODUCTION

DBS-STN for Parkinson Disease (PD) can either improve or deteriorate gait. Postural stability can also be affected by the disease and its therapy.

The aim of our study was to investigate the possible differences in kinematics, gait asymmetry and balance before and after DBS-STN.

PATIENTS/MATERIALS and METHODS

10 consecutive PD subjects before and after 3 months of DBS-STN (all subjects at ON condition) were included in the study using 3D Gait Analysis (temporal, kinematics, kinetics & EMG). Balance analysis was also performed using a force platform system (20 sec - Eyes Open & Eyes Closed protocol). 14 normal controls were also studied. Finally Gait Graph Asymmetry Indexes (GGAI)[1] were calculated. Paired t-tests were used to identify differences before and after DBS neurosurgery and t-tests for independent samples to identify significant mean differences between the PD patients and the control group.

RESULTS

Gait velocity increased significantly post surgery from 0.98 ± 0.36 (m/sec) to 1.15±0.27 (p=0.042) mainly due to an increased in step length from 0.51±0.22 to 0.61±0.13. Cadence decreased from 127.84±44.28 (steps/min) to 115.70±12.33. Although we found no statistically significant differences for the rest of the kinematic parameters and balance indexes, there was trend for improvement post surgery in almost all of the parameters measured.

Mean GGAI for gait graphs improved from 1.41 before to 1.02 after DBS-STN. We also identified the greatest improvements in asymmetry in the pelvic rotation (PRE 1.80 - POST 0.96), foot progression (PRE 1.40 - POST 0.79) and knee flexion extension (pre 1.39 - post 0.90). Although these differences showed a consistent improvement of GGAI values none of them was found to be statistically significant.

DISCUSSION & CONCLUSIONS

The above results indicate that walking velocity is increased mainly due to increased step length. In addition the statistically significant lower gait velocity observed between controls and patients before DBS-STN, was eliminated. Static balance was found to be improved although the improvement was not statistically significant. The analysis of all gait graphs for the pre - post DBS-STN showed a consistent improvement in GGAI whilst the lack of statistically significant results can be attributed to small sample size. Further study with more patients is needed to confirm the significance of the findings.

REFERENCES

1. Darras N., Pasparakis D., Tziomaki M., Papavasiliou A., Dimitriadis D., Pentarakis M., Nestoridis C. Gait asymmetry graphs and indexes. Gait and Posture, ISSN: 0966-6362, Volume: 30, Issue: 2, Date: 2009-11-01

INTERACTION: TRAINING AND MONITORING OF DAILY-LIFE PHYSICAL INTERACTION WITH THE ENVIRONMENT AFTER STROKE

Jaap H Buurke[1], Chris T.M. Baten[1], Jasper Reenalda[1], Corien D.M. Simons[1], Andreas R. Luft[2], Danillo De Rossi[3], Henk J. Luinge[4], Rita Paradiso[5] and Peter H. Veltink[6]

[1]Roessingh, Research and Development, Enschede, The Netherlands
[2]University Zurich, Neurology Department, Zurich, Switzerland
[3]University of Pisa, Research Centre , Pisa, Italy
[4]Xsens Technologies B.V, Enschede, The Netherlands
[5]Smartex s.r.l., Pisa, Italy
[6]University of Twente, Biomedical Signals and Systems, MIRA Institute, Enschede, The Netherlands

INTRODUCTION

Persons who suffered a stroke are trained to improve adequate control over their movements with the objective to optimize their daily-life functional performance. Critical is how good they are able to interact physically with the daily-life environment, including handling objects, controlling body balance during functional ambulation and while interacting with the environment.Continuous daily-life monitoring of the functional activities of stroke survivors, in their physical interaction with the environment, is essential for optimal guidance of rehabilitation therapy by medical professionals and coaching of the patient. Such information cannot be obtained with present monitoring systems. It is therefore the objective of the INTERACTION project to develop and validate an unobtrusive and modular system that enables monitoring the quality of daily-life activities and physical interactions with the environment. The INTERACTION project is partially funded by the European Commission under the 7th Framework Programme (FP7-ICT-2011-7-287351)

PATIENTS/MATERIALS and METHODS

In order to realise the I NTERACTIONconcept, the following methods are used. Instrumented textiles (shoes, trousers, shirt and gloves) with integrated textile-based and micromechanical sensors, to unobtrusively sense muscle activation (EMG), interaction forces and body movements. Methods for qualitative and quantitative assessment of the dynamic interaction of a person with the environment, identifying activity tasks during daily-life and evaluating the quality of performance of these tasks, applying task-dependent performance criteria. Telesupervision and intelligent on-body feedback, well integrated in clinical training concepts

RESULTS

The project builds on the results of former research [1]:Instrumented textiles developed at the University of Pisa [2,3]. Method to assess human body balance using instrumented shoes [4]. Method to assess power exchange with the environment from inertial movement sensing and interaction forces [5]

DISCUSSION & CONCLUSIONS

The user requirements and technical specifications of the INTERACTION system are defined and a first prototype consisting of the different state of the art technologies is being built. In the future new technologies will be incorporated in the INTERACTION system which will be evaluated in an experimental clinical setting, simulating daily-life conditions and demonstrated under daily-life conditions in stroke survivors.

REFERENCES

1. De Rossi D. et al. IEEE Engineering in Medicine and Biology Magazine, vol. 29, issue 3, 2010, pp. 37-43.
2. Lorussi F. et al. IEEE sensors Journal, vol.4, no. 6, 2004 pp.807-818.
3. Pacelli M. et al. proceedings of the 3rd Summer School and Symposium on mMedical devices and biosensors, MIT, Boston, USA, Sept. 4-6, 2006
4. Schepers H.M. et al.IEEE transactions on Biomedical Engineering, vol. 56, 2009, pp. 1189-1195.
5. Veltink P.H. et al. IEEE Transactions on Biomedical Engineering, vol. 56, 2009, pp. 1711-1718.

P91

IMPROVING WALKING ABILITY BY SURGICAL CORRECTION OF EQUINOVARUS FOOT DEFORMITY IN PATIENTS WITH STROKE OR TRAUMATIC BRAIN INJURY: A SYSTEMATIC REVIEW.

Jaap H. Buurke[1], Bertjo Renzenbrink[2], Anand V Nene[3] and Johan S. Rietman[1]

[1]Roessingh, Research and Development, Enschede, The Netherlands
[2]Roessingh Rehabilitation Center, Stroke unit, Enschede, The netherlands
[3]Roessingh Rehabilitation Center, Enschede, The Netherlands

INTRODUCTION

Equinovarus foot deformity following stroke or traumatic brain injury compromises walking ability, interfering with daily- and social activities [1]. In soft tissue surgery the imbalanced muscles responsible for the deviant position of the ankle and foot are lengthened, released and/or transferred [2]. Knowledge regarding the effectiveness of soft tissue surgery for correcting equinovarus deformity of the foot is limited. The aim of the present study was to review systematically the literature to assess the effects of surgical correction of equinovarus foot deformity in patients with stroke or traumatic brain injury.

PATIENTS/MATERIALS and METHODS

A systematic search of full-length articles in the English, German or Dutch languages published from 1965 to March 2011 was performed in PubMed, EMBASE, CINAHL, Cochrane and CIRRIE. The identified studies were analysed following the International Classification of Functioning, Disability and Health.

RESULTS

Fifteen case series and case control studies (CEBM level 4) were identified [3], suggesting that surgical correction of equinovarus foot deformity is a safe procedure that is effective in terms of re-obtaining a balanced foot position, improving walking capacity and diminishing the need for orthotic use.

DISCUSSION & CONCLUSIONS

Further validation of surgical correction of equinovarus foot deformity following stroke or traumatic brain injury, using high level study designs (prospective cohort, RCT) with validated assessment tools, is required. Comparing surgical techniques and comparing applicable interventions is necessary to generate evidence upon which treatment algorithms can be built.

REFERENCES

1. Dobkin BH. Clinical practice. Rehabilitation after stroke. N Engl J Med 2005 Apr 21;352(16):1677-1684.
2. Keenan MA. The management of spastic equinovarus deformity following stroke and head injury. Foot Ankle Clin 2011 Sep;16(3):499-514.
3. OCEBM Levels of Evidence Working Group. "The Oxford 2011 Levels of Evidence".
Oxford Centre for Evidence-Based Medicine. http://www.cebm.net/index.aspx?o=5653.

PREVENTION OF KNEE HYPEREXTENSION IN STROKE PATIENTS USING A KNEE ORTHOSIS: 3D COMPUTATIONAL GAIT ANALYSIS AND DYNAMIC EMG

Asaf Frechtel[1], Sigal Portnoy[1], Eitan Raveh[2] and Isabella Schwartz[1]

[1]Hadassah Medical Center, The Rehabilitation Department, Jerusalem, Israel
[2]Chemitec Advanced Medical Solutions, Hod Hasharon, Israel

INTRODUCTION

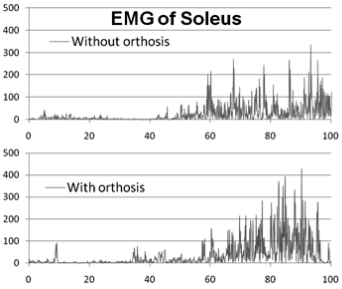
Post-stroke patients often suffer from knee hyperextension, which may damage their joints and elongate the stance duration. Orthoses are often prescribed for the management of knee hyperextension. The Genu Neurexa orthosis (Otto Bock, Germany) is designed to stabilize the knee, enable balance control and prevent hyperextension. Our aim is to evaluate the effect of the Genu Neurexa orthosis on the gait and muscle activity patterns in chronic stroke patients.

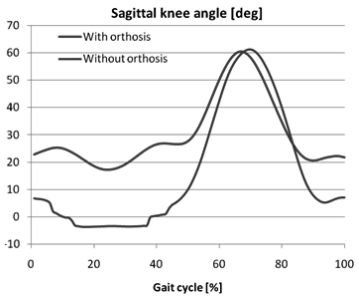
PATIENTS/MATERIALS and METHODS

The ongoing research will evaluate 60 post-stroke patients. The subjects are tested on enrolment and randomly divided into groups: group A ambulates with the orthosis for 4 weeks while group B does not receive intervention. The subjects are then retested. Then, group A ambulates without the orthosis and group B ambulates with the orthosis for additional 4 weeks. Both groups are retested after 8 weeks. The evaluation tools include functional evaluation, computational gait analysis (spatio-temporal parameters and kinematic data), synchronized with dynamic electromyography (EMG).

RESULTS

Interim results show improvement from baseline after ambulating with the orthosis for one month in BERG balance scale (increase in average from 33.5 to 37.7; $p<0.01$) and 6MWT (165.9 to 203.3; $p<0.05$). Symmetry of base width improved in most patients. The maximal and minimal sagittal knee angles significantly increased while ambulating with the orthosis by 10.5° and 19.9°, respectively ($p<0.001$). Partial patient data are presented below.





DISCUSSION & CONCLUSIONS

Interim results suggest the orthosis prevents knee hyperextension and increases knee flexion in swing, balance control and functional measures, thereby reducing the risk of falling.

REFERENCES

Bleyenheuft C, et al. Treatment of genu recurvatum in hemiparetic adult patients: a systematic literature review. *Ann Phys Rehabil Med*. 53:189-99, 2010.

SOFT TISSUE SURGERY FOR ACQUIRED EQUINOVARUS FOOT AFTER STROKE

Marc J Nederhand[1], Gerbert J Renzenbrink[1], Adelgunde VCM Zeegers[2], Anand V Nene[1] and Jaap H Buurke[1]

[1]Roessingh, Centre for Rehabilitation, Roessingh, Research and Development, Enschede, The Netherlands
[2]Medisch Spectrum Twente, Orthopedic surgery, Enschede, The Netherlands

INTRODUCTION

Equinovarus foot caused by central motor neuron disorder like stroke compromises positioning of the foot at initial contact and makes walking barefoot difficult. Equinus may result in secondary knee (hyper) extension; varus increases the risk of ankle sprain. Ankle Foot Orthosis (AFO) to correct the foot position is the common treatment in stroke. Surgical correction of fixed or dynamic foot deformities is not a widespread treatment option in adults with stroke[1] although results in CP are satisfying. Soft tissue surgery of the equinovarus foot is reported to normalize ankle foot position[2] and to decrease the need for orthotic treatment. The objective of this study was to explore the possibility of soft tissue surgery as a routine intervention as an alternative to orthotic bracing.

PATIENTS/MATERIALS and METHODS

15 patients, at least one year poststroke with a gait pattern with inversion and equinus in swing and/or stance phase, participated in the study. All patients underwent surgery with a combination of a Split Anterior Tibial Tendon transfer (SPLATT) and lengthening of achilles tendon or gastrocnemius muscle and additional procedures to correct clawing of the toes. SPLATT was only performed when selective or synergistic force of dorsiflexion was MRC $\geq$ grade 4. Pre and post assessments included: 1) Visual (split screen video) observation of gait (blinded for treatment) with the (modified) Rivermead Visual Gait Assessment (RVGA), 2) subjective impression of walking with the Foot and Ankle Ability Measure (FAAM) and 3) walking speed. The modified RVGA included additional assessment of the hindfoot position during stance and swing and the position of the toes.

RESULTS

The (modified) RVGA showed most improvement in the items foot positioning at initial contact and varus of the foot during swing. The results of the FAAM demonstrated an improvement in the ability to walk on uneven surface and walking up and down stairs. Walking speed did not improve on average, with high variability between subjects. No surgical or post operative complications were reported.

DISCUSSION & CONCLUSIONS

A combination of surgical interventions to correct deformities of both the foot and toes seems a satisfying alternative treatment when an AFO is inadequate to correct the foot deformity or patient satisfaction with orthotic use is low. Improvement is most evident when negotiating uneven terrain and stairs. Knowledge of muscle functioning and dynamics is necessary to decide on the choice and extensiveness of the surgical interventions.

REFERENCES

[1] Improving walking ability by surgical correction of equinovarus foot deformity in patients with stroke or traumatic brain injury: a systematic review. GJ. Renzenbrink et al, accepted 2012

[2] Carda_Gait Changes After Tendon functional surgery for equinovarus foot in patients with stroke. Am J Phys Med Rehabil 2009;88:292–301.

THE INFLUENCE OF BALANCE SUPPORT ON THE METABOLIC COST OF WALKING IN STROKE PATIENTS DURING OVERGROUND AND TREADMILL WALKING

Trienke IJmker[1, 2], Ameerani Jarbandhan[2], Daniëlle Rijntjes[3], Claudine J.C. Lamoth[4], Han Houdijk[1, 2]

[1]Rehabilitation Center Heliomare, Heliomare Research & Development, Wijk aan Zee, the Netherlands
[2]VU University Amsterdam, Research Institute MOVE; Faculty of Human Movement Sciences, Amsterdam, the Netherlands
[3]Rehabilitation Center Heliomare, Department of Physical Therapy, Wijk aan Zee, the Netherlands
[4]University Medical Center Groningen; University of Groningen, Center for Human Movement Science, Groningen, the Netherlands

INTRODUCTION

Stroke patients often suffer from a highly increased energy cost of walking[1]. Previous research suggests that balance control, which is an essential prerequisite for safe and independent walking and is often impaired in stroke patients, could be an important contributing factor to this increased energy cost[2-3]. In this study we examined the effect of impairments in balance control on energy cost of walking, by investigating the effect of balance support on energy cost during treadmill and overground walking in stroke patients with varying degrees of walking ability.

PATIENTS/MATERIALS and METHODS

Twentyfour stroke patients participated in this study (mean age 50.3 years; 7 females). Of these, 12 subjects relied on a walking aid in daily life (dependent walkers), whereas 12 subjects did not (independent walkers). All subjects completed four 5-minute walking trials at preferred walking speed: (1) supported overground walking with a cane, (2) unsupported overground walking, (3) supported treadmill walking using one handrail, and (4) unsupported treadmill walking. Energy cost (J/kg/m) was calculated from oxygen consumption data collected with a pulmonary gas exchange system.

RESULTS

Treadmill walking resulted in a significantly higher energy cost than overground walking during both supported and unsupported walking. On the treadmill energy cost was on average 16% lower while walking with handrail support compared to unsupported treadmill walking. Providing support during overground walking did not result in significant changes in energy cost for the whole group. However when comparing subgroups, dependent walkers showed a significant decrease in energy cost of 8% during supported compared to unsupported overground walking, whereas independent walkers showed a slight but significant increase (6%) in energy cost.

DISCUSSION & CONCLUSIONS

Results indicate that the increased energy cost observed during walking after stroke partly originates from impaired balance control. Subjects with a lower walking ability (dependent walkers) benefit most from support, whereas independent walkers even suffered from detrimental effects on energy cost of support during overground walking. Both the energy cost of walking and the effect of support on energy cost of walking were higher on the treadmill, implying that treadmill walking imposes higher demands on balance control.

REFERENCES

1.Detrembleur C., Gait Posture. 2003;18(2):47-55.
2.Donelan JM., J Biomech. 2004;37(6):827-835.
3.Houdijk H., Gait Posture. 2010;32:321-326.

WALKING PATTERN AND NEURAL CONTROL IN INCOMPLETE SPINAL CORD INJURY

Lea Awai[1], Marc Bolliger[1] and Armin Curt[1]

[1]University Hospital Balgrist, Spinal Cord Injury Center, Zürich, Switzerland

INTRODUCTION

Patients with an incomplete spinal cord injury (iSCI) undergoing locomotor training improve their walking capacity within limited boundaries [1]. They show some increase in walking speed and distance and they remain able to modulate some of their walking characteristics. Very often, walking speed is used as a primary outcome measure for an improved walking capacity and to rate the success of rehabilitation or interventions [2, 3]. In impaired gait of individuals suffering from a neurological disease, walking speed and dependent time-distance parameters may not be appropriate and sensitive enough to detect relevant changes of gait. In SCI, the question of cortically controlled aspects of gait as opposed to spinally mediated gait characteristics arises. Thus, outcome measures that describe specific deficits of impaired gait are of need. We therefore describe kinematic outcome measures that take into account the specific features of a spinal gait.

PATIENTS/MATERIALS and METHODS

This case series study includes 5 iSCI patients (48.0 ± 19.6 years) with different etiologies and levels of lesion. All patients were required to have a minimal walking capacity to perform over-ground and treadmill walking without the assistance of a person and were classified as AIS D on the ASIA impairment scale. To assess kinematic data, we used an infrared camera system to track passive markers on bony landmarks of the lower body.

RESULTS

Our data show that patients are able to vary their step length or cadence in order to achieve a higher walking speed within a range that is much smaller than in healthy individuals. Looking at inter-joint coordination and the control of distal limb placement reveals that these aspects of gait remain relatively invariant over time and show only little responsiveness to interventions such as rehabilitative physical therapy or pharmacological interventions. We did not find a spinal gait pattern present in all subjects suffering from a spinal cord lesion, but we found different groups with a characteristic gait pattern.

DISCUSSION & CONCLUSIONS

The results suggest that the control of walking cadence and step length can be voluntarily modulated by the patients while the more complex inter-joint coordination (involving the control of multiple joints and body segments) are neither changing during clinical recovery nor due to voluntary training. The findings reveal that some parameters of the human gait are under involuntary spinal control (neuronal networks such as central pattern generators), which are less responsive to inputs from cortical motor regions. This is in contrast to elements of the human gait that can be more efficiently controlled and trained by the iSCI patients.

REFERENCES

[1] Dobkin, B. H., D. Apple, et al. (2003). "Methods for a randomized trial of weight-supported treadmill training versus conventional training for walking during inpatient rehabilitation after incomplete traumatic spinal cord injury." Neurorehabil Neural Repair **17**(3): 153-167.

[2] Dobkin, B., D. Apple, et al. (2006). "Weight-supported treadmill vs over-ground training for walking after acute incomplete SCI." Neurology **66**(4): 484-493.

[3] Harkema, S. J., M. Schmidt-Read, et al. (2011). "Balance and Ambulation Improvements in Individuals With Chronic Incomplete Spinal Cord Injury Using Locomotor Training-Based Rehabilitation." Arch Phys Med Rehabil.

ASSESSMENT OF GAIT KINEMATIC GRAPHS PATHOLOGY DIFFERENCES, AMONG HEMIPLEGIC, DIPLEGIC & QUADRIPLEGIC CP PATIENTS USING ASYMMETRY VS. DEVIATION PLOTS.

Nikolaos Darras[1], Magda Tziomaki[1], Christos Nestoridis[1], Manoussos Pentarakis[1] and Dimitris Pasparakis[2]

[1]ELEPAP, Gait & Motion Analysis Center, Athens, Greece
[2] "Aglaia Kyriakou" Children Hospital, 2nd Orthopaedic Dept, Athens, Greece

INTRODUCTION

AD plot is a new gait analysis data reduction tool that has been developed recently[1]. This tool allows the study of gait kinematic graphs pathology through the quantification of deviation from normal values along with the quantification of the inherent asymmetry. The aim of the study was to use ADplots in order to study the diferences in the gait graphs of the sagittal, frontal and transverse plane among Hemiplegic, Diplegic and Quadriplegic CP patients.

PATIENTS/MATERIALS and METHODS

53 Hemiplegics, 156 Diplegics and 58 Quadriplegics were included in the study. Gait Graph Deviation Indexes and Gait Graph Asymmetry Indexes were calculated[1] . Both indexes are measured in Normal SD units. Plot format: Horizontal axis shows Asymmetry values & Vertical axis shows Deviation values. Sagittal plane (Hip, Knee and Ankle), Frontal plane (Hip & Knee) and Transverse plane (Hip) graphs were use in the analysis. ANOVAs were used to assess differences among groups.

RESULTS

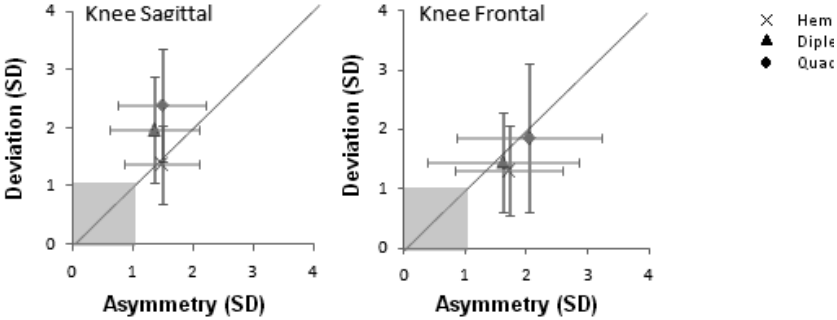


Figure1. Example Summary ADplots for the Knee Sagittal & Frontal plane- (Mean Asymmetry ± SD [X-axis] vs. Mean Deviation ± SD [Y-axis]). Graphs like figure 1, were plotted for all planes and all CP groups. Significant differences in asymmetry were found only between Diplegics & Hemiplegics in the sagittal plane graphs of the Hip and Ankle. Also, significant differences in deviation were registered among the CP three groups in the sagital and frontal planes.

DISCUSSION & CONCLUSIONS

The analysis of the three CP groups revealed their gait graph pathology diferences in deviation and asymmetry. In the sagittal plane, the factor of deviation is more pronounced than the asymmetry for Quadriplegics and Diplegics. Hempilegics show equal deviation and asymmetry in the sagittal plane. Quadriplegics asymmetry values were comparable to Hemiplegics. Finally, in the frontal and transverse plane graphs, all CP groups were found to exhibit more asymmetry than deviation.

REFERENCES

[1] Darras, N, Pasparakis, D, Tziomaki M, Nestoridis, C, Pentarakis M., Papandreou N. Asymmetry vs. Deviation Plot: A new Gait Analysis Data Reduction Tool. Proceedings of 20th Conference of ESMAC, Vienna (2011).

PHYSIOTHERAPEUTIC TREATMENT IN TEMPOROMANDIBULAR DISFUNCTION PATIENTS: ELECTROMYOGRAPHY STUDY

Daniela Aparecida Biasotto-Gonzalez[1], Tabajara de Oliveira Gonzalez[2], Politti Fabiano[2], Yasmin El Hage[1], Cid Andre Fidelis de Paula Gomes[2], Dowglas Fernando Magalhães Sousa[1], Graziela Fernanda Aparecido[3], Carolina Marciela Herpich[4], Cesar Ferreira Amorin[5] and Fausto Berzin[6]

[1]July Nine University , Master of Rehabilitation Sciences, São Paulo, Brazil
[2]July Nine University , Physiotherapy, São Paulo, Brazil
[3]July Nine University , graduation, São Paulo, Brazil
[4]
[5]Cidade de São Paulo University , Physiotherapy Master´s Program, São Paulo, Brazil
[6]College of Dentistry, State University of Campinas, Morphology, Piracicaba, Brazil

INTRODUCTION

Studies indicating[1,2] muscular unbalance as the triggering factor for TMD are present in the literature, and the role of the physiotherapeutic intervention on these dysfunctions should be analyzed. Thus, the goal of this research was to evaluate the physiotherapeutic treatment in patients presenting mandibular deviation or deflection, according to the electromyographic activity of temporal and masseter muscles bilaterally, along with assessing mandibular movement and patient's symptomatology (VAS).

PATIENTS/MATERIALS and METHODS

Seventeen female TMD patients with abnormal electromyographic patterns participated in this study. The average age of the groups was 23.7±4.15, and they were divided into the treated group and a control group. After accomplishing the first phase of the research (collection of EMG activity) Group 2 was submitted to 15 physiotherapeutic sessions of thirty minutes each, five times per week. The muscular relaxation technique utilized for the massage therapy was sliding, kneading, intra-oral, and stretching. Mandibular exercises were performed with the aid of Hiperboloide[1], and the proprioceptive training was performed with the tongue-against-hard palate technique, essential for re-establishing mandibular and tongue movement coordination[2].EMG exam was redone once the 15 proposed sessions were accomplished. The exam was performed in all the 17 subjects, so the EMG signal could be analyzed and compared. For the statistical analysis, the correlation degree between the collected variables was also verified. The Pearson's Coefficient of Correlation was executed. The alpha value utilized was 0,05 for the statistical test to reject the nullity hypothesis.

RESULTS

The results acquired in this study show that, through the data collected, a decrease in the RMS average value of all the muscles after treatment, except the right masseter muscle. Even though a decrease can be observed in the RMS average value for the treated muscles, the alteration was not considered statistically significant according to the executed test. The volunteers presented a significant decrease in symptomatology through the pre and post evaluation of the scores regarding VAS.

DISCUSSION & CONCLUSIONS

It was observed with the masticatory proprioceptive exercises an increase in articular coordination and realignment in the treated group.The study performed by Biasotto-Gonzalez e Berzin[2] demonstrated the positive outcome of massage therapy in patients with bruxism.This reduction in the electromyographic activity was also observed in the masticatory muscles analyzed and assessed in this research.

REFERENCES

[1]Biasotto-Gonzalez DA. Abordagem Interdisciplinar das Disfunções Temporomandibulares. 1ª ed. São Paulo: *Manole*, 2005

[2]Biasotto-Gonzalez DA., Berzin,F. Electromyographic study of patients with masticatory muscles disorders, physiotherapeutic treatment (massage). *Braz J Oral Sci* 2004; 3(10): 516-521

USE OF THE GAIT PROFILE SCORE AND MOVEMENT ANALYSIS PROFILE IN PATIENTS WITH PARKINSON'S DISEASE DURING DUAL TASK

Paulo Roberto Garcia Lucareli[1], Danielli Specialli[1], Elaine Menezes Oliveira[2], Jefferson Cardoso[3], Richard Baker[4] and João Carlos Ferrari Correa[1]

[1]Universidade Nove de Julho, São Paulo, Brazil
[2]Universidade Federal de São Paulo, São Paulo, Brazil
[3]Universidade Estadual de Londrina, Paraná, Brazil
[4]University of Salford, United Kingdom

INTRODUCTION

Gait disorders are common in individuals with PD and the concurrent performance of motor and cognitive tasks can have marked effects on gait.[1] The Gait Profile Score (GPS) and the Movement Analysis Profile (MAP) were developed in order to summarize the data of kinematics and facilitate understanding of the results of gait analysis. The GPS can be broken down to furnish the Gait Variable Score (GVS), based on nine values related to kinematics, and establish a MAP, which describes the magnitude of the deviation of nine individuals variables related to the gait cycle.[2-4] The aim of the present study was to investigate the effectiveness of the GPS/MAP in the quantification of changes in gait during a dual task (DT) performed by adults with and without PD.

PATIENTS/MATERIALS and METHODS

Fourteen patients with diagnosis of idiopathic PD (PDG) and nine healthy subjects (CG) participated in the study. All subjects performed single (walking free) and dual walking tasks (arithmetic subtraction regressive test). The kinematics data were collected using 3DGA VICON MX 40 system (Oxford Metrics Group; UK) from a minimum of six trials per subject. The GPS/MAP was computed from three-dimensional gait analysis data. Analysis of variance (ANOVA) was used for comparisons between groups. For the overall GPS, two-way ANOVA was used considering group and task as the factors. For others variables, three-way ANOVA was used considering side, group and task as the factors. Interactions between variables were also analyzed. The probability (p) smaller than 0.05 was considered to indicate statistical significance.

RESULTS

Statistically significant differences were found between groups for all GPS and GVS variables. Differences were found between tasks regarding the GPS (left, right and overall) and GVS (knee flexion-extension, ankle dorsiflexion-plantar flexion, pelvic obliquity, pelvic rotation, hip internal-external and foot internal-external rotation). In the comparison of sides, differences were found in the GPS (left and right) and GVS (hip flexion-extension, ankle dorsiflexion-plantar flexion, pelvic obliquity, hip adduction-abduction, pelvic rotation, hip internal-external and foot internal-external rotation). No interactions between side and task or side, task and group were observed. An interaction between task and group was only observed for the overall GPS.

DISCUSSION & CONCLUSIONS

Using this approach it has been possible to verify different compensation strategies adopted by PD and health subjects during DT interference. Our results showed that the GPS/MAP were effective not only to give a global overview of the gait deviation respect to normality, but also to illustrate quantitatively the overall changes in pathological walking as a result of a particular DT interference. GPS and particularly its MAP decomposition may be useful for clinical practice and provide information about the changes in movement pattern.

REFERENCES

[1] O'Shea S et al. Physcal Therapy 2002; 82:888-97. [2] Baker R et al. Gait&Posture 2009; 30: 265–9. [3] Beynon S et al. Gait&Posture 2010; 32: 129-32. [4] Baker R et al. Gait&Posture. 2012; 35:612-615.

ARE EFFECTS OF THE SYMMETRIC AND ASYMMETRIC TONIC NECK REFLEXES STILL VISIBLE IN HEALTHY ADULTS

Sjoerd M Bruijn[1], Firas Massaad[1], Leen Van Gestel[1] and Jacques Duysens[1]

[1]Dept. of Kinesiology, K.U.Leuven, Motor Control Laboratory, Research Center for Movement Control and Neuroplasticity, Leuven, Belgium

INTRODUCTION

In 1924 Magnus was the first to describe that when a cat's head is rotated in a transverse plane to one side, the legs on that side of the body extended, while on the other side, they flexed (Asymmetric Tonic Neck Reflexes) On the contrary, when the head was rotated in a sagittal plane both legs flexed when the head flexed, and they extended when the head extended (Symmetric Tonic Neck Reflexes). These so called Asymmetric/Symmetric Tonic Neck Reflexes were later found to also exist in newborn babies (Gesell, 1938), and are thought to be a motor primitive, which is suppressed later in life. Still, using a test in which children sit on hand and knees, and rotate their head to left and right, Parr et al (1974) were able to show that effects of the ATNR can be found in children up to 9 years of age. This is interesting, as it may suggest that these reflexes may still be involved in motor control in these children. Whether this is also the case in full-grown adults was investigated by Hellebrandt et al (1962) who reported clear effects of the ATNR. However, the methods used in the latter study were rather coarse, relying on photograms of subjects. Thus, for the current study, we set out to measure in detail whether the ATNR/STNR can still be evoked in healthy adult subjects. We did so with the future aim to look at the role of the ATNR/STNR in motor control during everyday movements, such as walking while looking in another direction.

PATIENTS/MATERIALS and METHODS

We measured 10 subjects (8 males, age: 22.2 ± 3.1 years length: 1.77 ± 0.1 m mass: 70.5 ± 12.9 kg). Subjects were asked to sit on their hands an knees while (1) Their head was flexed and extended by an experimenter, (2) they were asked to actively flex and extend their head, (3) their head was rotated left and right by an experimenter, (4) they were asked to actively rotate their head left and right. For each of these movements, three repetitions were performed and each movement was maintained around 5 seconds at the end. Kinematics were registered using a Vicon system (Plugingait fullbody markerset). Elbow and head angles were detrended, and a regression analysis was performed, to investigate the effects of head angle on elbow angle.

RESULTS

For both conditions involving flexion/extension movements of the head (i.e. active and passive flexion/extension), positive regression coefficients were found for all subjects, indicating that subjects flexed the elbows when the head was flexed, and extended them when the head was extended. For both active and passive rotations however, the left elbow showed a positive regression coefficient, while the right elbow showed a negative regression coefficient, indicating that the left arm extended when the head turned left, and flexed when the head turned right, while the right arm did the opposite, as predicted by the ATNR.

DISCUSSION & CONCLUSIONS

We were able to precisely quantify the existence of the ATNR and STNR in adult subjects. A next step will be to assess the effects of the ATNR and STNR during everyday motor control tasks, such as walking while looking in a different direction.

REFERENCES

Gesell A. The tonic neck reflex in the human infant. *journal of Pedriatics* 13: 455, 1938. **Hellebrandt FA, Schade M, and Carns ML**. Methods of evoking the tonic neck reflexes in normal human subjects. *Am J Phys Med* 41: 90-139, 1962. **Magnus R**. *Korperstellung*. Berlin: Julius Springer, 1924. **Parr C, Routh DK, Byrd MT, and McMillan J**. A developmental study of the asymmetrical tonic neck reflex. *Dev Med Child Neurol* 16: 329-335, 1974.

COMPARISON OF THE EFFECTS OF TWO FATIGUE PROTOCOLS ON TRICEPS SURAE MUSCULOTENDINOUS STIFFNESS

Zahra Rojhanishirazi[1] and Marzieh Saadat[1]

[1]School of rehabilitation, physical therapy, shiraz, iran

INTRODUCTION

Although some studies have investigated the effects of muscle fatigue(1), there is no report about the effect of fatigue on musculotendinous stiffness of the triceps surae or on the duration of this effect. This study was designed to compare the effect of two fatigue protocols on musculotendinous stiffness of the triceps surae up 15 minutes flowing procedures.

PATIENTS/MATERIALS and METHODS

Twenty university students participated in this study. Musculotendinous stiffness of the triceps surae was measured before and after a fatigue protocols which comprised continuous isometric voluntary plantar flexion contraction (25% maximum voluntary contraction and 70% maximum voluntary contraction) until contraction could no longer be maintained (1-2). The free oscillation technique was used to measure musculotendinous stiffness of the triceps surae (3). A Kistler force plate was used to measure the force applied.

RESULTS

Musculotendinous stiffness decreased immediately after both fatigue protocols ($P < 0.05$).Data analysis with a generalized linear model showed that stiffness of the triceps surae tendon differed significantly before and after both of fatigue protocols and the decrease in stiffness remained constant for 15 min after the fatigue protocols, also, there was not significant difference between the effect of two fatigue protocol with respect to the change of stiffness ($P>0.05$).

DISCUSSION & CONCLUSIONS

Musculotendinous stiffness of the triceps surae decreased significantly after both fatigue protocols. This may reflect a creep event for the tendon during prolonged isometric contractions. Change in musculotendinous stiffness last for 15 min after the fatigue task. This may reflect long lasting effect of fatigue on musculoskeletal and neuromuscular systems.

REFERENCES

[1] Blackburn JT, A. Padua DS, Weinhold PM, Guskiewicz K. Comparison of triceps surae structural stiffness and material modulus across sex. Clinical Biomechanics. 2006;21:159–67.

[2] Blackburn J, Padua D, Guskiewicz K. Muscle stiffness and spinal stretch reflex sensitivity in the triceps surae. Journal of Athletic Training. 2008;43(1):29-36.

[3] Murphy AJ, Watsford ML, Coutts AJ, Pine MJ. Reliability of a test of musculotendinous stiffness for the triceps surae. Physical Therapy in Sport 2003; 4 :175–181.

GASTROCNEMIUS FUNCTION ON ANKLE AND KNEE DURING GAIT

Christian Wyss[1] and Reinald Brunner[1]

[1]University Children's Hospital (UKBB), Laboratory for movement analysis, Basel, Switzerland

INTRODUCTION

Several tools to determine the total force acting on a body segment are available. The models from ANYBODY and OpenSim are well known. Soft tissue procedures (botulinum toxin, surgery) address muscle groups globally today. Knowing the contribution of the individual muscle to joint control could offer a more appropriate treatment. In this respect it is interesting how the total force of the gastrocnemius muscle splits up to move the knee and to drive the ankle.

PATIENTS/MATERIALS and METHODS

The "GaitLowerExtremity" model from the ANYBODY Repository AMMRV1.4.1 and ANYBODY Version 5.1 was used to determine the muscle forces of the lower leg during gait. Gait analysis data of a healthy subject and a tetraspastic patient were used. Two force plates (AMTI) and a standardised "Plug in Gait" marker setup (Vicon Oxford Metrics) was used to collect the data. The "GaitLowerExtremity" model was slightly changed and adapted for the "Plug in Gait" marker setup. The ANYBODY model obtained the data input from the c3d files of this gait analysis. The total force oft the gastrocnemius muscle in this original model (OM) was then determined using a min/max function (Rasmussen, 2001). In a second analysis a submodel (SM1) was created where the hip and ankle joint were driven by constraints and not by muscles. This procedure allowed calculating the muscle force of the gastrocnemius muscle driving the knee only. In a second submodel (SM2) hip and knee were controlled by constraints and the muscle forces driving the ankle was determined. The two submodels were put in one model(SM1+SM2). This is entirely possible in ANYBODY. The percentual distribution of muscle force needed to drive the knee and ankle joint only in model (SM1+SM2) is easily to determine. Assuming that the percentual distribution of muscle force in model SM1+SM2 and in model OM is the same, the determination of muscle force contributing to knee and ankle joint control can be calculated from model OM.

RESULTS

Figures 1 and 2 show the distribution of gastrocnemius muscle force at the ankle (red) and knee (blue).

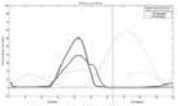


figure 1: Healthy

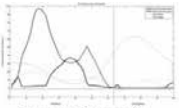


figure 2: Tetraspastic

The force at the ankle is much higher in a tetraspastic individual compared with a healthy subject. Furthermore there is a peak of gastrocnemius force in the early stance phase in the tetraspastic patient only. The force at the knee in contrast is reduced in the tetraspastic, but in the same phase as in the healthy.

DISCUSSION & CONCLUSIONS

Replacing muscles by drivers enables to determine the percentage and amount of an individual muscle on separate joint levels even in biarticular muscles. To our knowledge it is the first time that the force of the gastrocnemius muscle was divided up for knee and ankle movement separately. This principal approach can be applied for muscles in general.

REFERENCES

Rasmussen, J., Damsgaard, M., Voigt, M., 2001. Muscle recruitment by the min/max criterion - a comparative numerical study. Journal of Biomechanics 34 (3), 409–15.

IS SLOPE WALKING LESS STABLE IN FRONTAL PLANE THAN LEVEL WALKING?

Oliver Rettig[1], Daniel W. W. Heitzmann[1], Julia Block[1] and Sebastian I. Wolf[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

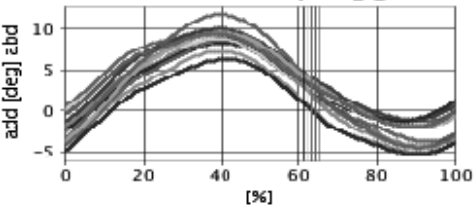
Slope walking shows different gait patterns than level walking but only a few studies have attempted to analyse it. This study focusses on the frontal plane and medio lateral balance for healthy subjects. The work is made with regard to have a reference for analysing subjects with lower limb protheses and balancing arm movements.

PATIENTS/MATERIALS and METHODS

Ten healthy subjects (22-43 years, 7 males, 3 females) with no histories for neurologic, orthopedic and vestibular diseases participated in the study. 3d-kinematic data is collected with a 12-camera Vicon system while walking on level ground as well as ascending and decending (2.5°/5.0°/7.5° inclined surfaces) at their normal self-selected speed. The Vicon's lower body "Plugin-Gait model" is combined with an upper extremity model [1] for fullbody gait analysis. A "gait-line" is defined as projection of the pelvis center (mid point of the three markers placed on the pelvis) to the floor. Step width is determined as orthogonal distance of the "foot midpoint" (mid point between ankle joint center and toe marker) to the gait-line at foot strike. Stride width is defined as sum of corresponding left and right step width. A combined center of mass for both arms together (ArmsCoM) is calculated and its position relativ to the upright is determined as a projection angle in the frontal plane (ad-/abduction).

RESULTS

Stride width and standard deviation is enhanced with increased inclination angle, e.g. between level walking and uphill walking on 7.5° inclined surface there is a mean difference about (10±20)%. The figure shows ad-/abduction movement of the ArmsCoM normalized to 100% of a gaitcycle for different strides of the same subject. No differences are found in ArmsCoM pattern between level and up-/downhill walking on inclined surfaces with different inclination angles. Furthermore no differences are found in the amplitudes of the maximum in stance phase and the minimum in swing phase and also no differences are found in its position in the gaitcycle.



DISCUSSION & CONCLUSIONS

Larger stride width compensate for higher needs to achieve medio lateral balance during slope walking. Increased standard deviation can be interpreted to show less stability but for healthy subjects the arms are not involved in compensation.

REFERENCES

[1] Rettig, O., et al., Gait Posture 30 (2009) 469-476

VALIDITY AND RELIABILITY OF NEWLY DEVELOPED HIP MUSCLE STRENGTH TESTS

Christophe Meyer[1, 2], Kristoff Corten[2], Mariska Wesseling[3], Jean-Pierre Simon[2], Ilse Jonkers[3], Kaat Desloovere[1]

[1]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[2]UZ Leuven, University Hospital Pellenberg, Orthopedic department, Pellenberg, Belgium
[3]KU Leuven, Department of Movement Sciences, Leuven, Belgium

INTRODUCTION

Isokinetic dynamometer is considered the golden standard for muscle strength testing. The studies dedicated to the hip joint revealed that participants' positioning is of paramount importance: standing vs lying position[1, 2]. Different testing positions and methods, in a variety of population, highlighted variable reliability results for hip torque measurements[3, 4]. This study aimed to develop a standardized test set-up for the assessment of hip muscle strength with an optimal patient stability and to define the psychometric characteristics of these setups.

PATIENTS/MATERIALS and METHODS

A total of 5 men and 2 women, with a median (and interquartile range) age of 30 (26,5-33,5) years, height of 180 (176-183) cm, weight of 77,2 (65,6-85,6) kg and body mass index of 23,81 (21-26,9) kg/m², volunteered to participate in this study. Isometric and isokinetic peak torques were assessed using the Biodex dynamometer during two test sessions, separated by one week interval. Hip abduction/adduction and hip flexion/extension were performed at a concentric/concentric mode after a 10 minutes warm-up cycling exercise. Participants first performed 3 submaximal repetitions, followed by 3 isokinetic contractions at 60°/s and 120°/s and finally 3 sustained isometric (6s) contractions. A sufficient rest period (up to 5 minutes) was always set between the different testing position and condition. The new testing positions, where focus was given to stabilization using straps and braces, are presented in figure 1. Test-retest reliability of peak torque was assessed via the intra-class correlation (ICC) coefficient (2,1)[5]. The standard error of measurement (SEM) was calculated as well the minimum detectable change at the 95% confidence interval (MDC_{95})[6].

RESULTS

Figure 1: A) Hip Abduction/Adduction test. B) Hip flexion/extension test

Table 1: Intraclass correlation values for the different motion tests with the reported standard errors of measurement (SEM) expressed in Newton meters

	Peak torque	Peak torque 60°/s	Peak torque 120°/s
Hip Abduction	0.93 (10,22)	0.91 (12,11)	0.90 (12,41)
Hip Adduction	/	0.69 (16)	0.74 (15,65)
Hip Flexion	0.98 (2,47)	0.97 (8)	0.93 (9,96)
Hip Extension	0.72 (23,06)	0.88 (12,52)	0.72 (23,06)

DISCUSSION & CONCLUSIONS

This study revealed that our new hip muscle strength setups allow more reliable and repeatable measures of maximal hip contractions for hip abduction and hip flexion that could have been measured until now (≥0,90). The least reliable measures were found for hip extension and hip adduction, which could be explained by a less efficient stabilization technique.

REFERENCES

[1] Barbic S et al.. Arch Phys Med Rehabil 2008.
[2] Claiborne TL et al. J Electromyogr Kinesiol 2009.
[3] Arokoski MH et al. J Rheumatol 2002.
[4] Widler KS et al. J Bone Joint Surg Am 2009.
[5] Shrout PE and Fleiss JL. Psychol Bull 1979.
[6] Stratford PW. Physiotherapy Canada 2004.

COMPARISON OF THE EFFECT OF SELECTED MUSCLE GROUPS FATIGUE ON POSTURAL CONTROL DURING BIPEDAL STANCE IN HEALTHY SUBJECTS

Zahra Rojhanishirazi[1] and Fatemeh Nikhalat[1]

[1]School of Rehabilitation, physical therapy, Shiraz, Iran

INTRODUCTION

The maintenance of balance is an essential requirement for the performance of daily tasks and sporting activities and muscular fatigue is a factor to impair postural control[1], so this study was done to compare the effect of selected muscle groups fatigue on postural control during bipedal stance in healthy subjects.

PATIENTS/MATERIALS and METHODS

Fifteen healthy female students (24.3±2.6 years) completed three testing sessions with a break period of 2 days. During each session, postural control was assessed during two 30-s trials of bipedal stance[2] before and after the fatigue protocol. Fatigue protocols were performed by 60% of their Maximum Voluntary Contraction[3] of ankle plantar flexors, lumbar extensors and neck extensors. **.** Measurements of maximum voluntary contraction (MVC) and fatigue protocols were performed by using dynamometer (MIE, LTD, UK) and the force platform (Kistler Switzeland, type 9286 AA).

Fifteen healthy female students (24.3±2.6 years) completed three testing sessions with a break period of 2 days. During each session, postural control was assessed during two 30-s trials of bipedal stance[2] before and after the fatigue protocol. Fatigue protocols were performed by 60% of their Maximum Voluntary Contraction[3] of ankle plantar flexors, lumbar extensors and neck extensors. **.** Measurements of maximum voluntary contraction (MVC) and fatigue protocols were performed by using dynamometer (MIE, LTD, UK) and the force platform (Kistler Switzeland, type 9286 AA).

RESULTS

Mean center of pressure (COP) velocity was compared between pre and post fatigue across the three muscle groups.The result showed that fatigue had a significant effect on COP velocity and it can increase COP velocity but there was not any significant difference in postural control between fatigue of different muscle groups.

DISCUSSION & CONCLUSIONS

Localized muscle fatigue caused deficits in postural control regardless of the location of muscle fatigue**.** Authors suggest the possibility of the contributions of central mechanisms to postural deficits due to muscle fatigue**.**

REFERENCES

•1. Salavati M, Moghadam M, Ebrahimi I, Massoud Arab A. Changes in postural stability with fatigue of lower extremity frontal and sagittal plane movers. Gait& Posture 2007; 26:214–18.
•2.Lin D, Nussbaum MA, Seol H, Singh NB, Madigan ML, Wojcik LA. Acute effects of localized muscle fatigue on postural control and patterns of recovery during upright stance: influence of fatigue location and age. Eur J Appl Physiol 2009;106: 425-34.
•3.Kavanagh JJ, Morison S, Barret RS. Lumbar and cervical erector spinae fatigue elicit compensatory postural responses to assist in maintaining head stability during walking. J Apple Physiol 2006;101(4):1118-26.

DO DIFFERENT WALKING PATTERNS WHICH ARE SEEN IN CHILDREN WITH CEREBRAL PALSY CAUSE STIFF KNEE GAIT IN HEALTHY PEOPLE?

Ekin N. Akalan[1], Shavkat N. Kuchimov[2], Adnan Apti[3] and Yener Temelli[4]

[1]Istanbul University, Faculty of Healt Science, Physiotherapy and Rehabilitation Division and Istanbul Faculty of Medicine, Division of Orthopedics and Traumathology, Gait Analysis Laboratory, Istanbul, Turkey
[2]Bogazici University, Institute of Biomedical Engineering, Istanbul, Turkey
[3]Istanbul University, Faculty of Healt Science, Physiotherapy and Rehabilitation Division, Istanbul, Turkey
[4]Istanbul University, Istanbul Faculty of Medicine, Division of Orthopedics and Traumathology, Istanbul, Turkey

INTRODUCTION

Stiff knee is very common gait pattern for children with cerebral palsy. Radical stretching exercises and distal rectus femoral transfer operation are applied for these children in clinic. Although, outcomes shows that there is great inconsistency for stiff knee gait pattern. Where some of the children have good knee flexion in swing phase some have not. The purpose of the study was to investigate tip toe gait pattern results in stiff knee and to analyze the relations between rectus femoris muscle stiffness and stiff knee. It is also interested if different gait behaviors are valuable enough for deep biomechanic investigation.

PATIENTS/MATERIALS and METHODS

Mimicking tip-toe, mimicking toe-in and normal walking pattern of 6 healthy participants, aged 20-25 were analyzed by 3D gait analysis system in Istanbul Faculty of Medicine, Motion Analysis Laboratory. Peak knee flexion time and angle, total knee range in whole gait cycle, knee range and duration from toe off to peak knee flexion were measured. Four gait parameters were selected as measuring criteria of whether a subject walked with a stiff-knee gait: i.peak knee flexion angle, ii.range of knee flexion between toe-off to peak knee flexion, iii.total range of knee flexion, and iv.time of peak knee flexion in swing. A limb was considered as ‘‘stiff’’ if 3 or more, and as ‘‘not-stiff’’ if one or none of the criteria were indicative of stiff-knee gait. If two of the measures were indicative of stiff-knee gait, the limb was classified as a borderline case. Paired t-test was used for the statistical comparison of 3 different gait patterns ($p<0.05$).

RESULTS

Peak knee flexion angle significantly reduced in both toe-in gaited ($p<0.02$) and tip-toed ($p<0.0001$) groups relative to normal, total knee range also significantly reduced in tip toed (52.4°) and toe-in gaited (49.96°) groups ($p<0.0001$). Range between toe-off and peak knee flexion diminished only in in-toed group ($p<0.0001$) relative to normal as we have seen in stiff knee gait pattern. Duration of time between toe-off and peak knee flexion also increased in both toe-in gaited (18.64ms) and tip toed (16.41ms) groups relative to normal (16.38ms) but the differences were not statistically significant ($p<0.95$, $p<0.11$ respectively).

DISCUSSION & CONCLUSIONS

Both toe-in gaited and tip-toed gait patterns caused reduction of peak knee flexion angle and total knee range. For in toed walking, range between toe-off and peak knee flexion also diminished. The extended duration of time between toe-off and peak knee flexion was the only parameter that was not affected by walking pattern, whereas, toe-in gait pattern itself is the reason of stiff knee gait. Although tip-toe gait causes border line stiff knee pattern in typically developed participants.

REFERENCES

[1] Goldberg SR, Ounpuu S, Arnold AS, Gage JR, Delp SL, Kinematic and kinetic factors that correlate with improved knee flexion following treatment for stiff-knee gait. Journal of Biomechanics 2006; 39:689-698

[2] Desailly E., et al. Rectus femoris transfer and musculo-skeletal modeling: Effects of surgical treatment on gait and on rectus femoris kinematics. Gait and Posture (2011), doi:10.1016/j.gaitpost.2011.07.005

DIFFERENT STABILIZING EFFECT OF TAPE, KINESIOTAPE, AND ANKLE BANDAGE IN JUMP LANDING WITH CHRONIC ANKLE INSTABILITY

Benita Kuni[1], Johannes Mussler[1], Eva Kalkum[1], Merkur Alimusaj[1], Nikolaus A Streich[1], Holger Schmitt[1] and Sebastian I Wolf[1]

[1]Heidelberg University Hospital, Department of Orthopedics, Trauma Surgery and Spinal Cord Injury, Heidelberg, Germany

INTRODUCTION

Untreated ankle sprains can lead to recurrent injuries and chronic ankle instability [1]. External ankle support reduces the number of ankle sprains [2]; however, we do not know which device stabilizes the ankle joint complex most effectively in dynamic situations. Therefore, the aim of this study was to quantify the effect of different types of support (kinesiotape, classic white tape, and bandage (Malleotrain, Bauerfeind)) on foot kinematics during landing by means of the Heidelberg Foot Measurement Method (HFMM) [3].

PATIENTS/MATERIALS and METHODS

We evaluated 20 patients (11 F, 9 M, 25.9 y. mean (3.6 y. SD)) with chronic ankle instability by instrumented 3D motion analysis with a 12-camera system (Vicon) using the HFMM. In order to reproduce the exact anatomic position of the markers despite the tape/bandage, a device with laser pointers was employed. Segmental foot kinematics were analyzed in drop falls (from a 35-cm height) followed by 2 s. of stabilization on one leg.

RESULTS

Classic taping and the bandage reduced the range of motion of subtalar eversion as compared with the barefoot condition, whereas the kinesiotape did not influence this parameter. All three devices signficantly reduced plantarflexion in landing. The maximal lateral tilt of the medial arch and the range of motion of the medial arch were reduced by classic taping.

DISCUSSION & CONCLUSIONS

Segmental foot analysis clearly showed the stabilizing effect of both classic taping and the bandage. The tape seems to provide stiffer conditions in the midfoot. Since we analyzed a dynamic situation, our results are useful in the clinical setting as advice for preventing ankle sprains. The effect of kinesiotape needs to be clarified by further investigations.

REFERENCES

[1] Hertel J (2000) Functional instability following lateral ankle sprain. Sports Med 29 (5):361-371

[2] Handoll HH, Rowe BH, Quinn KM, de Bie R (2011) WITHDRAWN: Interventions for preventing ankle ligament injuries. Cochrane Database Syst Rev (5):CD000018. doi:10.1002/14651858.CD000018.pub2

[3] Simon J, Doederlein L, McIntosh AS, Metaxiotis D, Bock HG, Wolf SI (2006) The Heidelberg foot measurement method: development, description and assessment. Gait Posture 23 (4):411-424. doi:10.1016/j.gaitpost.2005.07.003

BIOMECHANICAL DIFFERENCES BETWEEN EXPERIENCED AND INEXPERIENCED WHEELCHAIR USERS DURING SPORT

Ambreen Chohan[1], Starrs Paul[1], David Fewtrell[1], Richards Jim[1] and Selfe James[1]

[1]University of Central Lancashire, School of Sport, Tourism & the Outdoors, Preston, United Kingdom

INTRODUCTION

This study focused on the biomechanical differences between experienced and inexperienced manual wheelchair users (MWCU) whilst taking part in sport. Data collection was performed at The Cheetahs Wheelchair Sports Club in Thornton-in-Cleveleys, Lancashire, UK. Their objective is to create a level playing field for disabled children with regards to sport, by allowing able bodied children to take part in disabled sporting activities with the disabled children. Environmentally, this sports club removes the barriers which previously would not allow disabled children to take part in sport. This increases the participation opportunities for disabled children and promotes improvements in health and wellbeing. MWCU can execute different propulsion techniques. It is believed inexperienced MWCU execute pumping propulsion, which is a stroke that possess a highest metabolic cost [1]. Trunk flexion, a common compensatory movement for inexperienced MWCU, generates power that the upper limbs of these MWCU are incapable of as they exhibit characteristics associated with low efficiency [2]. Experienced MWCU, on the other hand, depend solely on their upper-limbs for efficient movement. Consequently, inexperienced MWCU need to produce trunk flexion as they tire more readily. This study examines if experienced and inexperienced MWCU differ regarding upper limb movement patterns when completing functional wheelchair tasks.

PATIENTS/MATERIALS and METHODS

11 participants were divided into two groups; WCU (experienced) (n = 7) and NWCU (inexperienced) (n = 4). The participants in the WCU category had been attending The Cheetahs for, on average, 8.5 months compared to the NWCU who had been attending for 6.75 months. All participants were asked to perform three functional tasks; 30 second agility test, 1 minute distance test and a10 metre sprint test [3]. Upper body kinematics were recorded using a XSens MVN BIOMECH motion capture suit.

RESULTS

The NWCU outperformed the WCU in all of the tasks however no significant differences between the group's results were found. Significant differences were found in the maximum shoulder flexion angle for both right and left with NWCU utilising more flexion and near significant differences in the NWCU overall shoulder range for right and left.

DISCUSSION & CONCLUSIONS

Although WCU refine their propulsion technique on a day to day basis it is thought that the reason why the NWCU outscored the WCU on the functional tests is due to the larger range of movement they utilised during propulsion. In order to increase function in young MWCU then specific activity based sessions should be implemented to help the user adopt an effective propulsion technique that utilises large ranges of motion in the joints responsible for efficient movement. Employing a propulsion technique which uses larger ranges of shoulder motion and decreased push rim frequency results in an optimal cost-effect balance without predisposing MWCU to overuse injuries

REFERENCES

[1] de Groot, S., *et al.* (2004). *American Journal of Physical Medicine and Rehabilitation*. **83**(8): 640-649.

[2] Rodgers, M.M., *et al.* (2000). *Journal of Rehabilitation Research and Development.* **37**(3): 283-295.

[3] Tanaka, N., *et al.* (2010). *Japanese Journal of Physical Fitness and Sports Medicine.* **59**: 131-142.

CORRELATION OF FOOT-STRIKE PATTERN AND PERFORMANCE IN A MID-SIZE CITY MARATHON

Mark E Kasmer[1] and Xue-cheng Liu[2]

[1]Medical College of Wisconsin, Physical Medicine & Rehabilitation, Milwaukee, USA
[2]Medical College of Wisconsin, Orthopedics, Milwaukee, USA

INTRODUCTION

A small number of studies have provided "in-race" foot-strike prevalence of runners in mid- to long-distance races. The recent studies each classified the foot-strike of less than 300 runners in half-marathon and marathon races. The runner populations varied from all elite runners to mostly "recreational" runners. The prevalence of heel-strike ranged from 74.9% to 93.0%. Correlation with performance, however, has been impossible due to the small sample sizes. Using a seven-fold larger runner population, this study aims to more accurately define the prevalence of heel-strike in a mid-size city marathon and to determine if a correlation between foot-strike and performance exists.

PATIENTS/MATERIALS and METHODS

2112 runners in the 2011 Milwaukee Lakefront Marathon were filmed at the 5.02-mile mark using a Casio EX-ZR100, with a frame rate of 240 frames per second. The camera was securely mounted at a height of 24" and a distance of 12" from the side of the road. The camera was angled at 30 degrees from a direct lateral, or perpendicular angle. Foot-strike classification was determined by a 3-member panel utilizing frame-by-frame analysis. Classifications included fore-foot strike, mid-foot strike, heel strike, and split strike (asymmetric between consecutive foot-strikes).

RESULTS

1991 runners were classified by foot-strike pattern: 11 fore-foot (0.55%), 101 mid-foot (5.07%), 1865 heel (93.67%), and 14 split (0.70%). The heel-strike prevalence of 93.67% was more prominent than in prior studies of both recreational and elite runners. A correlation was demonstrated between foot-strike and performance (as measured by position in race at the 5.02-mile mark), with a p-value < 0.0001. Fore-foot strikers were followed by split-strikers, then mid-foot strikers, then heel-strikers. There was no significant correlation demonstrated between foot-strike and gender (p-value = 0.0727).

DISCUSSION & CONCLUSIONS

This study is the largest "in-race" observational study of marathon runners to date. It unequivocally demonstrates: a) heel-strike prevalence in a predominantly sub-elite population of runners is significantly greater than previously documented in more elite running populations and b) foot-strike is correlated with performance (as measured by position in race). Shoe wear (minimalist versus traditional) was not correlated with position in race in non-heel strikers, perhaps placing more emphasis on foot-strike than shoe wear for performance. Further research is necessary to elucidate whether non-heel strike running form produces a faster runner or a faster runner produces a non-heel strike running form.

REFERENCES

1. Hasewaga H. et al (2007). Foot strike patterns of runners at the 15-km point during an elite-level half marathon. *Journal of Strength and Conditioning Research*, 21, 888-893.

2. Kerr B. et al (1983). Footstrike patterns in distance running. In Kerr (Ed), *Proceedings of the International Symposium on Biomechanical Aspects of Sport Shoes and Playing Surfaces* (pp. 135-142). Calgary, Alberta: University Press.

3. Larson P. et al (2011). Foot strike patterns of recreational and sub-elite runners in a long-distance road race. *Journal of Sports Sciences*, 29, 1665-1673.

FIELD STUDY OF A LOW-COST MARKERLESS MOTION ANALYSIS FOR REHABILITATION AND SPORTS MEDICINE

Loreen Pogrzeba[1], Markus Wacker[1] and Bernhard Jung[2]

[1]University of Applied Sciences Dresden, Faculty of Information Technology/Mathematics, Dresden, Germany
[2]TU Bergakademie Freiberg, Faculty of Mathematics and Computer Sciences, Freiberg, Germany

INTRODUCTION

A motion capture system (short: MCS) allows therapists an objective insight into motion of the patient and enables to validate the therapy success numerically and objectively over several sessions. However, traditional MCSs have some disadvantages: They often require trained personel, much technical equipment and maintenance and may be expensive and non-portable. Moreover they are not suited for patients, who cannot bear long preparation times with markers and suits or become too distracted by a technical set-up. Thus we're targeting on the development of a low-cost, portable, user-friendly, and markerless MCS for use in rehabilitation and sports medicine.

Therefore we work together with therapists of the Swedish function oriented music therapy (FMT) and International Vojta Society (IVS), training theorists of the Olympic Training Center Dresden (OTC) und sport medicine specialists of the University Hospital Carl Gustav Carus Dresden (HCGC).

PATIENTS/MATERIALS and METHODS

Our MCS consists of the Microsoft Kinect sensor and a self-developed software based on the open available Kinect libraries such as the Microsoft SDK or OpenNI. The recording of motion runs simultaneously in a distance of about 2.5 m and 1.6 m in height in front of the patient while he or she is performing the exercises. The software displays the video image, a simplified human skeleton in a freely adjustable 3d view and selectable motion graphs for position and rotation data of up to 24 bones in realtime. The therapist can evaluate the therapy sessions by replaying and scrolling the motion streams, adding comments, displaying motion trajectories and changing the choice of displayed motion graphs.

In the field of FMT and IVS there are participants of all ages who can be suffering of i.a. cerebral palsy and other birth related injuries, scoliosis, hip joint dysplasia, mental retardation, ADHD, muscular diseases and psychiatric problems. The set-up at the HCGC focuses on gait analysis of nonprofessional athletes and therewith is added to a treadmill.

RESULTS

Recording tests with FMT and HCGC have proven that our MCS is well suited for practical use. Recording speed, accuracy and stability were completely satisfactory for the tested areas of application. Our project partners found it easier to detect and evaluate irregular or asymmetric motion, e.g. limping or asymmetric body postures while playing drums.

DISCUSSION & CONCLUSIONS

With the support of a non-contact therapeutic analysis module a new quality of treatment can be achieved. Full physical body functions can be restored much faster and more goal-oriented. Due to the low-cost Kinect sensor our MCS is easy affordable for clinics and self-employed therapists. It works nearly invisible, needs no prior preparations and therefore is ideally suited for patients with fear of contact, athetosis, twitches, tremors, autism and dementia.

In conclusion the FMT therapists and HCGC specialists are very eager to use our MCS independently for longer periods. In addition recording tests with IVS and OTC will take place in April and May in Germany and FMT studies with a larger number of participants will most likely follow this August in Sweden. For that reason it is planned to develop the MCS further, so that it detects and tags comparable motion patterns automatically. The next hardware version of the Kinect sensor will also raise the quality level of the camera image and the precision of the data.

REFERENCES

THE EFFECT OF DIFFERENT BREAST SUPPORT CONDITIONS ON MULTIPLANAR BREAST KINEMATICS AND KINETICS DURING RUNNING

Davide Monari[1], Kaat Desloovere[2, 3], Lynn Bar-On[2], Guy Molenaers[3], Ellen Jaspers[2]

[1]KU Leuven, Department of Production engineering, Machine design and Automation (PMA), Leuven, Belgium
[2]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[3]University Hospital Pellenberg, CMAL, Pellenberg, Belgium

INTRODUCTION

Excessive breast movement when excercising has been associated with pain and repeated loading of the breasts' supporting structures. This in turn may lead to permanent deformation of the supporting structures and consequently breast ptosis. Whilst previous studies showed that fitted sport bras are effective in reducing the amplitude of breast displacement during walking and (treadmill) running,[1-3] the effect on breast kinetics has not yet been reported. Moreover, studies thus far only included larger breasted women.

PATIENTS/MATERIALS and METHODS

Eight female participants (28.6±6.0yrs) gave their written informed consent. Four women had a D-cup, three a B-cup and one an A-cup. Retro-reflective markers were placed following the ISB for the trunk coordinate system (TCS)[4], and on the nipples (over the bra). Marker tracking was done over 10 gait cycles at 8km h^{-1} for *two breast support conditions* (regular bra and fitted sports bra). *Multiplanar kinematics* included relative nipple marker displacement projected on the axes of the TCS in three directions: vertical (ROM_{vert}), mediolateral (ROM_{medlat}) and antero-posterior ($ROM_{antpost}$).[2] *Multiplanar kinetics* were calculated as the forces transferred through Cooper's ligaments (F_{Cooper}), the pectoralis fascia (F_{pect}), and the ribs (F_{ribs}). Breast mass was calculated as the breast volume[5] multiplied by adipose tissue density ($0.95 g/cm^3$).[6] Forces were calculated based on breast weight and mass, the dorsal angle of breast insertion, and the vector of sagittal plane linear acceleration of the breasts' center of mass.[7] Differences in ROM and peak forces between both breast support conditions were assessed using the *Wilxocon signed rank test*, with significance set at $p<0.05$.

RESULTS

The fitted sports bra resulted in a significant reduction of multiplanar kinematics and kinetics during running (Table 1).

Table 1. Median and interquartile range (IQR) of the breast displacement (mm) and force parameters (N) during treadmill running in two breast support conditions, with concurrent *p*-values.

	Regular bra		Fitted sports bra		Reduction	
	Median	(IQR)	Median	(IQR)	(%)[a]	p^b
ROM_{vert}	29.29	(25.05)	11.37	(13.39)	61	0.01
ROM_{medlat}	8.53	(4.72)	5.16	(1.10)	40	0.01
$ROM_{antpost}$	5.36	(2.23)	3.72	(0.92)	31	0.03
F_{cooper}	12.85	(6.93)	10.41	(4.65)	19	0.04
F_{pect}	5.27	(7.80)	4.99	(4.05)	5	0.04
F_{ribs}	6.85	(5.53)	5.91	(3.10)	14	0.04

[a] The reduction is calculated as the % difference between the median scores of the regular bra and the fitted sports bra; [b] Wilcoxon signed rank test

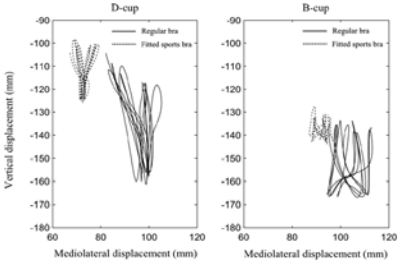


Fig 1: Vertical and mediolateral relative displacement of left breast for a representative smaller breasted (B-cup) and larger breasted (D-cup) subject.

DISCUSSION & CONCLUSIONS

This is the first study to include smaller breasted women in the 3D analysis of the effect of different breast support conditions. To reduce the repeated loading of the breasts' supporting structures, and hence minimize discomfort and the risk for developing breast ptosis, both smaller and larger breasted women should be encouraged to wear a fitted sports bra when exercising (Fig 1).

REFERENCES

[1] Scurr et al. J Sports Sci 2011;29:55-61; [2] Scurr et al. J Sports Sci 2010; 28:1103-9; [3] Scurr et al. J Appl Biomech 2009;25:322-9; [4] Wu et al. J Biomech 2005;38:981-92; [5] Gefen & Dilmoney Technol Health Care 2007;15:259-71; [6] Baldwin et al. J Plast Reconstr Aesthet Surg 2010; 63: 663-5; [7] El-Oteify et al. Indian J Plast Surg 2006;39:13-6.

THE GAIT PATTERN OF AN ELITE ATHLETE WITH LOW VISION: A CASE STUDY

Maria Gomez[1], Cristina Lopez de Subijana[1] and Enrique Navarro[1]

[1]Technical University of Madrid - INEF, Madrid, Spain

INTRODUCTION

It is known that visual information during locomotion is essential for perceiving self-motion, limb position and limb movement [1]. Some studies [1] [2] have demonstrated specific differences in gait patterns between people with and without low vision. The objective of the present study was to evaluate the gait pattern adaptations that could be found in a professional athlete with visual impairments.

PATIENTS/MATERIALS and METHODS

One Paralympic athlete with low vision participated in the study. A VICON optoelectronic system was used to capture the trials with six cameras, sampling at 250 Hertz.. A total of 42 retro-reflective markers were attached to anatomical landmarks. Four gait cycles from each lower limb were captured from the subject.

RESULTS

The non-parametric Mann-Whitney U-test showed significant differences between the present study and the Gillette Gait Index in adults data [3] ($p<0.05$). The time of toe off (% gait cycle) and the time of knee peak flexion (% gait cycle) were significantly earlier than the times of gait cycle showed in GGI in adults. Some movements in sagittal plane, like the maximal hip extension, the knee flexion at initial contact, the maximal ankle dorsiflexion at stance and swing and the mean foot progression angle in stance showed values significantly lower than GGI in adults. The results also showed a significant difference in the hip movement at stance in the coronal plane.

DISCUSSION & CONCLUSIONS

The findings of this study showed that the gait pattern in low vision athletes could have adaptations in sagittal plane, such a less hip extension, less knee flexion at initial contact and less ankle dorsiflexion during swing and stance [2]. There were found some others adaptations in coronal plane such an internal hip rotation at stance which altered the normal foot positioning [2]. Although it is presumably that an elite athlete could have an optimal self-perception of motion, results showed that gait pattern was similar to the untrained people with visual impairments.

REFERENCES

[1] Hallemans A, Ortibus E, Meire F, Aerts P. Low vision affects dynamic stability of gait. Gait & Posture 2010;32:547-551.

[2] Hallemans A, Beccu S, Van Loock K, Ortibus E, Truijen S, Aerts P. Visual deprivation leads to gait adaptations that are age-and context-specific: II.Kinematic parameters. Gait & Posture 2009;30:307-311.

[3] Creatual A, Bervet K, Ballaz L. Gillette Gait Index in adults. Gait & Posture 2010;32:307-310.

THE INFLUENCE OF DISCUS WEIGHT IN DISCUS THROWING

Andrzej Mastalerz[1], Jerzy Sadowski[1] and Lucyna Gwarek[1]

[1]University of Physical Education in Warsaw, Faculty of Physical Education and Sport, Biała Podlaska, Poland

INTRODUCTION

Several studies have reported significant individualized relationships between the release speed and the release angle in throwing events [1,2]. Different discus weight is often used in the condition of training and can influence on release parameters, however those conditions were not investigated in the literature. Therefore this study analyzed the influence of discus weight on selected kinematical parameters of the discus throwing.

PATIENTS/MATERIALS and METHODS

Three male and two female right-handed elite discus throwers performed four throws in sequence of following discus weight: 0,85 kg; 1,00 kg; 1,10 kg, 1,25 kg for women and 1,75 kg; 2,00 kg; 2,25 kg; 2,5 kg for men. The discus throwers' performances were recorded by two camcorders GR DVL-9800 operating at 60 frames per second and a shutter speed of 1/250 s. Camcorders positions and orientations were calibrated for a calibration volume of 1.5 m long x 1.5 m wide x 2.0 m high enclosing the discus-throwing circle. The video clips from both camcorders of each trial were manually digitized using a APAS videographic data acquisition system (Ariel Dynamics Inc., USA). The release speed (Vs), release angle (α), distance of the throw (R), distance between front foot and the discus on the x-axis (Rx), height of release (h), horizontal velocity of the discus (Vx), vertical velocity of the discus (Vy), knee angle (β), discus distanse (Sd) and distance of the throwers center of mass (Ssc) were estimated.

RESULTS

Table 1 and table 2 show the mean results obtained in the study respectively for women and men.

Tab. 1. Mean ± SD values of the parameters during discus throwing with different discus weight (D) in women

D [kg]	α [deg]	β [deg]	V [m/s]	h [m]	Sd [m]	Ssc [m]	Rx [m]	R [m]
0.85	34.9±0.3	138.9±19.0	23.9±1.5	1.38±0.17	17.15±0.25	2.84±0.08	-0.26±0.66	59.6±6.3
1	35.1±0.1	139.3±14.4	23.4±0.6	1.36±0.11	17.63±1.17	3±0.29	-0.23±0.71	55.5±7.7
1.1	35.6±1.3	132.4±25.4	22.5±0.6	1.4±0.06	17.34±0.57	3±0.14	-0.08±0.68	51.4±5.0
1.25	35.7±1.8	139.2±18.4	21.2±1.5	1.3±0.00	17.45±0.83	3.17±0.15	-0.2±0.66	47.5±6.1

Tab.2. Mean ± SD values of the parameters during discus throwing with different discus weight (D) in men

D [kg]	α [deg]	β [deg]	V [m/s]	h [m]	Sd [m]	Ssc [m]	Rx [m]	R [m]
1.75	33.9±1.4	125.6±12.7	24.3±0.7	1.52±0.13	17.51±0.75	3.08±0.13	-0.13±0.49	61.6±2.1
2	36.8±1.9	125.8±10.3	23.2±0.4	1.5±0.09	17.62±1.04	3.15±0.16	0.01±0.52	57.4±2.8
2.25	36.2±2.7	124.9±15.7	22.8±0.3	1.48±0.10	17.54±1.00	3.25±0.1	-0.03±0.4	54.4±1.5
2.5	35.7±2.8	123.7±10.8	22.1±0.4	1.55±0.20	17.23±0.80	3.28±0.3	0.06±0.5	51.0±2.3

DISCUSSION & CONCLUSIONS

The ideal angle of release for the discus throw is between 35-40 degrees [1]. The release angles preferred by elite discus throwers may not necessarily be optimal for themselves. The highest differences for the release angle were obtained for 1.75 kg discus (8%), other differences does not exceed 5% and except the lightest discus all values can be considered as optimal. According to the results achieved in our study and to other authors [2] we conclude that the discus weight mainly influenced on the release velocity.

Acknowledgment: Work financed from budgetary resources on science in the years 2011-2014 by the Polish Ministry of Science and Higher Education – grant no N RSA1 002251

REFERENCES

[1] Leigh, S., Liu, H., Hubbard, H., Yu, B. Journal of Biomechanics, 2010, 43(3), 540-545.

[2] Ariel G., Penny A., Finch Al., *Biomechanics in Sports XV, 365-371.*

IMPROVED WALKING ABILITY IN ELDERLY WITH OSTEOPOROSIS AFTER PARTICIPATING IN A BALANCE TRAINING PROGRAMME WITH DUAL- AND MULTI-TASKS

Alexandra Halvarsson[1, 2], Erika Franzén[1, 2], Agneta Ståhle[1, 2]

[1]Karolinska Institute, Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy , Stockholm, Sweden
[2]Karolinska University Hospital, Department of physical therapy, Stockholm, Sweden

INTRODUCTION

Falls and fear of falling are common in the elderly population, and in combination with osteoporosis a fall can be very costly for both the society and for the individual. Aging and fear of falling has an impact on walking ability, and when adding a secondary task, cognitive or motor, the gait pattern is further altered [1]. Previous studies have shown that walking ability in elderly can be improved by balance training [2]. The aim of this study was to evaluate the effect of a three months progressive balance training with focus on dual- and multi-tasks on spatial and temporal gait parameters in elderly with osteoporosis and self reported fear of falling.

PATIENTS/MATERIALS and METHODS

A total of 72 elderly (aged: 66-87 years) subjects with osteoporosis, self reported fear of falling and balance deficits were recruited by advertisement. Participants were randomized to either a training group (n=45) or to a control group (n=27). The training group participated in a progressive and highly challenging balance training program, with focus on dual- and multi- cognitive and/or motor tasks, during 12 weeks, three times a week, 45 minutes/session [2]. The control group was encouraged to continue with their usual activities, and were offered the same balance training at the end of the study. All subjects were assessed at baseline and directly after the intervention period. Gait parameters, i.e. velocity, cadence, step length, step width and double support phase were assessed using an instrumented walkway system (GAITRite). Participants walked at their preferred speed, as fast as they could without tripping and/or falling and at their preferred speed during a cognitive dual task (reciting every second letter of the alphabet). Each condition was performed six times and a mean value was used for analysis. For statistical calculations PASW Statistics version 19.0 was used. A Mixed model analysis was performed on all gait parameters. Statistical significance was set to ≤ 0.05.

RESULTS

Analysis over time and between groups after the intervention revealed significant differences all in favour for the training group compared to the control group. At preferred speed, with and without a cognitive dual-task, a significant increase was seen in velocity ($p=0.002$ and $p=0.034$ respectively) and cadence ($p=0.009$ and $p=0.029$, respectively). The participants in the training group increased their velocity with 13%during the dual-task condition, resulting in similar velocity during both conditions at preferred speed. During gait at fast speed, significantly increased velocity ($p=0.002$), cadence ($p=0.004$) and step length ($p=0.044$) were seen in the training group.

DISCUSSION & CONCLUSIONS

To participate in a three months progressive balance training programme will significantly improve walking ability, especially under dual- or multi-task conditions, in elderly with osteoporosis. This ability is important in daily life and may prevent hazardous falls, and also have positive impact on physical activity levels, contributing to a better general health.

REFERENCES

[1] Verghese J, Kuslansky G, Holtzer R, Katz M, Xue X, Buschke H, et al. Walking while talking: effect of task prioritization in the elderly. Arch Phys Med Rehabil. 2007 Jan;88(1):50-3.

[2] Halvarsson A, Olsson E, Faren E, Pettersson A, Stahle A. Effects of new, individually adjusted, progressive balance group training for elderly people with fear of falling and tend to fall: a randomized controlled trial. Clin Rehabil. 2011 Nov;25(11):1021-31.

QUANTIFYING MOTOR CONTROL OF THE KNEE DURING SIDE HOPS - HEALTHY SUBJECTS AND SUBJECTS ~20 YEARS AFTER ANTERIOR CRUCIATE LIGAMENT INJURY

Helena Grip[1], Eva Tengman[1] and Charlotte Häger[1]

[1]Physiotherapy, Dept. of Community Medicine and Rehabilitation, Umeå, Sweden

INTRODUCTION

Jumps are often used in the rehabilitation after an anterior cruciate ligament (ACL) injury to quantify movement capacity in e.g. number of jumps. There is a lack of measures that quantify changes in knee axis direction/ position during functional motion tasks, something that could give important information about motor control of the knee after e.g. ACL rupture. The aim of this study was investigate the applicability of variables based on the finite helical axis (FHA) [1] to measure the motor control of the knee during side hops, in healthy controls and ACL- injured subjects.

PATIENTS/MATERIALS and METHODS

The control group (CTRL) consisted of 33 subjects (age 45±5 years, BMI 24.6±2.5), and the ACL group of 70 subjects with a unilateral ACL-injury since 23±2 yrs. Of these, 37 were treated with tailored physiotherapy (ACL-PT,age 48±6 yrs, BMI 28.9±4.6) and 33 underwent reconstructive surgery 4±3 yrs after injury (ACL-RS,age 46±5yrs, BMI 27.2±3.3). Laxity at different loads(anterior shift of the tibia relative to the femur), was measured with a KT-1000 arthrometer. The Side Hop consisted of side hops on one leg; the subject was given 30 s to hop as many times as possible across two parallell lines taped on the floor 40 cm apart. Arms were held crossed over the chest. Movement was registrered with a motion capture system (Oqus®, Qualisys Gothenburg, Sweden, 240 Hz, 8 cameras). Movement variables based on an FHA model with a steplength of 20° were calculated in MATLAB (v7.12.0, R2011 a, Mathworks Inc., Natick MA). The Axis Direction Mobility Index (ADMI, range 0-1) was defined as the smallest through the largest eigenvalue of the matrix of FHA direction vectors during take-off and landing (a larger index corresponds to a larger direction change and possibly a lower stability). The Mean FHA Inclination with the thigh vertical axis, range of motion (ROM), translation of shank relative to thigh and number of hops were also calculated.

RESULTS

At a load of 30lb, side difference in anterior shift was 0.1±1.0 mm in CTRL group, 4.7±3.0 mm in the ACL-PT group and 2.1±2.7 mm in the ACL-RS group. Small but significant correlations were found in the CTRL group between KT-1000 and ADMI during Side Hop (R^2=0.15-0.23, non-dominant leg, $p<0.05$ in all cases). They also showed significantly larger ADMI, more vertical FHA inclination and smaller ROM during the landing than during take-off (repeated-measures ANOVA, $p<0.05$). Preliminary results from 10 of 37 ACL-PT subjects showed on average larger shank translations during take-off (11.0±8.0/9.4.0±7.0 mm, injured/non-injured leg) as compared with the CTRL group (6.1±4.0/6.3.0±4.5mm, dominant/non-dominant leg), which could relate to a larger movement span between femur and tibia, and on average a larger ADMI for the injured leg during takeoff (ACL-PT: 0.21±0.09/0.17±0.07, injured/non-injured leg, control: 0.15±0.06/0.18±0.08, dominant/non-dominant leg). The ACL-PT subjects also performed fewer hops (6±7/8±7, injured/non-injured leg than the CTRL group (11±5/10±4, dominant/non-dominant leg).

DISCUSSION & CONCLUSIONS

A small correlation between KT1000 and ADMI for the CTRL group could reflect that laxity had an impact on the motor control of the knee, even though many other factors e.g. muscle strength and co-ordination are important. A larger ADMI and more oblique mean FHA during the landing than takeoff in the CTRL group probably related to higher demands on motor control of the knee joint during this phase. Preliminary results from 10 ACL-PT subjects indicated negative effects from the ACL injury on the motor control of the injured knee.

REFERENCES

van den Bogert A.J., Reinschmidt C.,Lundberg A., Helical axes of skeletal knee joint motion during running, J Biomech, 2008, 41:1632-38

RELATIONSHIPS BETWEEN MUSCULAR ACTIVATION PATTERNS AND POSTURAL ORIENTATION IN PATIENTS WITH ANTEROR CRUCIATE LIGAMENT INJURY

Anna Trulsson[1], Gert-Åke Hansson[2], Christina Gummesson[1], Michael Miller[1] and Martin Garwicz[3]

[1]Lund University, Department of Health Sciences, Division of Physiotherapy, Lund, Sweden
[2]Lund University, Division of Occupational and Environmental Medicine, Lund, Sweden
[3]Lund University, Department of Experimental Medical Science, Neuronano Research Center, Lund, Sweden

INTRODUCTION

Anterior cruciate ligament (ACL) injury affects the ability to stabilize body segments in relation to each other and to the environment. This results in so called substitution patterns, which can be quantified with an observational test called Test for Substitution Patterns, TSP (1, 2), and deviant muscular activation patterns(3). Here, we introduce a method to characterize relationships between substitution patterns and deviant muscular activation patterns and present preliminary findings from patients and un-injured subjects.

PATIENTS/MATERIALS and METHODS

Two ACL-injured patients and four un-injured subjects participated. Subjects performed body-weight altering, mini-squat, knee flexion-extension on one leg, tiptoe standing knee-flexion-extension on one leg and forward lunge (1). Surface EMG was recorded (Mega Win ME6000) for gluteus med., biceps fem., quadriceps fem. vast. lat., tibialis ant., med. gastrocnemius and peroneus longus in right and left leg. Metronome was used for speed setting. Knee electrogoniometer was used to define start and end of movement. EMG during test movements was divided into 10 time bins for each muscle, with an 11^{th} 'pre-bin' for anticipatory activity. Average amplitudes for each bin were plotted in a diagram. The correlation coefficient, the intercept and the slope of the regression line were calculated to compare activity in corresponding muscles.

RESULTS

In the two ACL-injured patients, muscles in the injured lower leg had a high activity also before and after movements were performed, picked up by our method and yielded characteristic and quantifiable correlations with TSP scores. In the four un-injured subjects, the method allowed a quantification of intra-subject consistency and inter-subject variation when performing a given movement.

DISCUSSION & CONCLUSIONS

We present a method for EMG-analysis focused on comparing muscle activation patterns in ACL-injured patients with and without substitution patterns. Preliminary results indicate that the method allows a quantitative characterization between deviating muscle activation patterns and substitution patterns as measured by the TSP.

REFERENCES

1.Trulsson A, Garwicz M, Ageberg E. Postural orientation in subjects with anterior cruciate ligament injury: development and first evaluation of a new observational test battery. Knee Surg Sports Traumatol Arthrosc. 2010 Jun;18(6):814-23.

2.Trulsson A, Roos E M, Ageberg E, Garwicz M. Relationships between postural orientation and self reported function, hop performance and muscle power in subjects with Anterior Cruciate Ligament injury. BMC Musculoskeletal Disorders. 2010;11:143.

3.Ingersoll CD, Grindstaff TL, Pietrosimone BG, Hart JM. Neuromuscular consequences of anterior cruciate ligament injury. Clin Sports Med. 2008 Jul;27(3):383-404, vii.

GENERALIZED CHRONIC PAIN CONDITIONS AND THEIR RELATIONSHIP WITH GAIT PATTERN ALTERATIONS. A FIBROMYALGIA STUDY.

Irene Rodríguez[1], Ignacio González[1], Maria Teresa González[2] and Juan Andrés Martín[1]

[1]Physiotherapy School of the ONCE, Autónoma University, Madrid, Spain
[2]IPR, Gregorio Marañón Univ. General Hospital, Madrid, Spain

INTRODUCTION

Fibromyalgia is described as a non rheumatic disease of the musculoskeletal system characterized by generalized chronic pain, usually accompanied by fatigue and weakness. Its prevalence is high, around 2.4% in Spain, and between 2.9% and 4.7% in Europe. Although a chronic pain condition is thought to be responsible for movement and walking disturbances, there is little evidence about objective functional measurements in this group of patients. The aim of this study was to describe any walking alterations and to determine if there is a relationship between quality of life perception and gait parameters, 3D joint kinetics and kinematics during walking in a group of FM patients.

PATIENTS/MATERIALS and METHODS

35 patients diagnosed with primary FM according to the American College of Rheumatology criteria, were selected to enter the study. Exclusion criteria comprised presence of another musculoskeletal or neurological disease that may lead to gait disturbances. Patients completed the Spanish version of the Fibromyalgia Impact Questionnaire (FIQ) and the Fibromyalgia Health Assessment Questionnaire (FHAQ). GA was conducted using CODAmotiom cx1 system (Charnwood Dynamics Ltd, Leicester, UK) and a Kistler 9286A force platform. 7 patients were excluded due to not meeting quality criteria. Statistical analysis was performed using the generalized linear model and the Student, Pearson and Shappiro-Wilk tests. As a reference group, the normal sample of the Physiotherapy School of the ONCE gait laboratory was used. The level of significance used was 5%.

RESULTS

Gait parameters (GP) were significantly different in FM patients ($p<0.01$) except single support time ($p=0.3$). Speed was significantly slower ($p=0.0001$). However, no correlation was found between GP and FIQ/FHAQ scores, apart from percent stance ($p<0.05$). Significant differences were found in all kinematic and kinetic variables ($p<0.01$) save for pelvic rotation ($p=0.06$) and the anterior posterior component of GRF ($p=0.9$). No correlation was found between the kinetic/GRF variables and speed ($p=0.44$-0.76), unlike between kinematics parameters and speed ($p<0.003$). On the other hand, a strong correlation was found between most of these variables and the FIQ ($P=0.001$) and the FHAQ ($p=0.05$).

DISCUSSION & CONCLUSIONS

The results of this study suggest an altered gait in FM patients. It is characterized by slow gait velocity, larger bipodal time periods and lower cadence. Changes in practically all lower limb kinematics may show a slight instability during gait due to cautious walking pattern, however, joint kinematic alterations were also dependent of walking speed. On the other hand, a decreased hip and ankle extensor moment, mainly exhibited at moment of loading response and push off were not directly associated with a walking speed reduction, and may be attributed to functional weakness during GC. Although most of patients showed high scores in FIQ and FHAQ -where higher score indicates poor quality of life- a relationship between objective functional measurements and both, FIQ and FHAQ, were found only in some parameters, emphasizing the relationship between high scores on both questionnaires and lower joint torques at the hip and ankle during walking. The fact that kinetic changes were independent of walking speed and showed a significant relationship with poor quality of life perception, may point to another underlying factors for gait motor control alteration in FM. Further investigations are needed to confirm if GA, combined with FIQ and FHAQ, provide an useful tool to gait functional treatment and assessment in patients with FM. .

REFERENCES

GAIT ANALYSIS AFTER TOTAL HIP ARTHROPLASTY IN DYSPLASTIC HIP PATIENTS

Silvestris Zebolds, MD.[1], Andris Jumtins, MD, PhD[2], Zane Pavare, MD, PhD.[2] and Tatjana Ananjeva[2]

[1]State Hospital of Traumatology and Orthopaedics, Traumatology and Orthopaedics , Riga, Latvia
[2]Riga Stradins University, Orthopaedic, Riga, Latvia

INTRODUCTION

The dysplastic hip osteoarthritis(OA) patients (pts) are relatively young and mostly women in ages between 20 and 50[1]. The signs of OA are strongly associated with increasing age and severity of dysplasia[2]. The main complaints for dysplastic hip OA patients are pain, bad range of movements, instability and waddling gait. The aim of total hip artroplasty (THA) is to reduce these symptoms and to establish normal gait. For evaluation of functional outcome instumental gait analysis was performed after THA. The results were compared with the data of the control group (15 persons without any deseases that could influence the normal gait).

PATIENTS/MATERIALS and METHODS

In our study we examined 28 dysplastic hip OA pts who underwent 37 THAs (9 pts were operated bilaterally) in Riga State Hospital of Traumatology and Orthopaedics in 2009 and 2010. 22 pts were women, 6 - men. Average age was 48.7 years (32-65). In all cases cementless endoprostheses were used. Plain X-rays of the pelvis were performed pre- and postoperatively for assesment of the grade of dysplasia (due to Crowe's classification)[3] and evaluation of the cup placement (in the primary or secondary socket). Instrumental gait analysis was performed at least one year after THA for all 28 pts and for control group of 15 persons.

RESULTS

°Due to Crowe's classification there were 17 cases with grade I, 10 - grade II, 9 - grade III, 1 - grade IV dysplasia. In 11 cases the acetabular components of endoprostheses were placed in the secondary socket, in 28 cases - in the primary (anatomical) socket. Instrumental gait analysis showed that there was a difference in a distance and kinematic parameters in 2 groups (pts after THA and control group).The stance (floor contact period) phase duration in pts group was 64.18%, in control group 62.18%. The swing phase duration in pts group was 35. 82%, in control group 37,87%. In sagital plane hip joint range of motions (ROM) in pts group was 39.78°, in control group 30.47° . Maximal flexion (average) in swing phase in pts group was 34.51°, in control goup 31.46° , but in stance phase max extension in pts group (average) was -4.04 (hip joint leaved in slight flexion), in control group max extension was 8.32°. The ROM of pelvis (in sagital plane) was higher in pts group: 5.38 against 2.69° in control group.

DISCUSSION & CONCLUSIONS

Radical anatomical and biomechanical reconstruction of hip joint during THA may lead not only to local complications as overstretching of ischiadic nerve, contracture of hip joint, early loosening and wear of acetabular component of endoprosthesis, but even to the distress of the whole musculo-skeletal apparatus. In severe dysplasia cases (Crowe III, IV) the choice to locate the acetabular cup in the secondary socket can even reduce the possible complication rate. Conclusion. 1.The instrumental gait analysis at least one year after THA showed significant improvement of gait parameters (close to normal gait) in dysplastic hip OA patients. 2.There were no correlation between the functional outcome after THA and location of the acetabular component (in the primary or secondary socket).

REFERENCES

1.Wilkinson JA. A post-natal survey for congenital displacement of the hip. J Bone Joint Surg Br. Feb 1972;54(1):40-9.

2.Rebecca H. Jessel, BA, David Zurakowski, PhD, Cristoph Zilkens, MD et al., Radiografic and patient factors associated with pre-radiografic osteoarthritis in hip dysplasia // JBJS, 2009; 91 : 1120 -1129.

3.Crowe J.F., Many V.J., Ranawat C.S. Total hip replacement in congenital dislocation of the hip // JBJS, 1979; 61A : 15-23.

GAIT ANALYSIS USING A PORTABLE MOTION SENSOR SYSTEM: MEASUREMENTS IN SUBJECTS WITH HIP IMPLANT AS COMPARED WITH HEALTHY CONTROLS

Fredrik Öhberg[1], Helena Grip[1], Kjell G Nilsson[2], Urban Edström[1], Ola Gustavsson[1], Charlotte Häger[3], Ronnie Lundström[4, 5]

[1]Biomedical Engineering, Dept of Radiation Sciences, Umeå, Sweden
[2]Orthopaedics, Dept. of Surgical and Perioperative sciences, Umeå, Sweden
[3]Physiotherapy, Dept. of Community Medicine and Rehabilitation, Umeå, Sweden
[4]Biomedical Engineering, Dept of Radiation Sciences, , Umeå, Sweden
[5]Occupational Medicine, Dept. of Public Health and Clinical Medicine, Umeå, Sweden

INTRODUCTION

There is an increase of age related diseases such as hip joint arthritis, something that is often treated with hip replacement surgery. The aim of this study was to quantify movement function and its effect on quality of life in persons treated with hip implant, in comparison to matched asymptomatic controls.

PATIENTS/MATERIALS and METHODS

This is an ongoing study, and so far, 2 asymptomatic subjects (CTRL, age 50±13 years, BMI 23±2), and 4 subjects with hip implant (HIP, age 51±15 years, BMI 25±3), have been analyzed. The HIP group received their implant 2.6±1.1 years ago and finished their rehabilitation 1.6±1.1 years ago. Hip dysfunction and Osteoarthritis Outcome Score (HOOS) was used to assess the subject's hip function and its associated problems. A functional calibration (flexion/abduction movements) was done and each subject then performed 5 repetitions of gait (approx. 25 left/right gait cycles). Movement was registrered with a custom-developed portable motion sensor system, where each sensor consisted of a tri-axial accelerometer and gyroscope. Sensors were placed on pelvis and each thigh and shank. Further calculations were done in MATLAB (v7.12 R2011a, Mathworks). Cosine rotation matrices were extracted by functional sensor-to-segment-calibration and sensor fusion [1], and hip and knee angles were obtained as Euler angles.

RESULTS

Preliminary results indicated larger range in hip rotation and smaller range of knee flexion during gait in HIP group than in the CTRL group (**Fig 1**). HOOS profile (**Fig 2**) indicated that hip function during sports (SP) and the general quality of life (QOL) were lower in the HIP group.

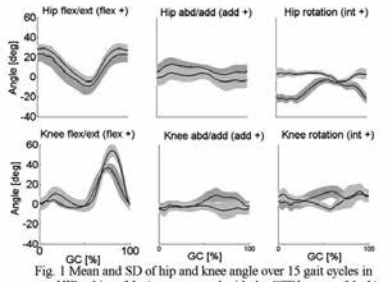


Fig. 1 Mean and SD of hip and knee angle over 15 gait cycles in one HIP subject (blue) as compared with the CTRL group (black).

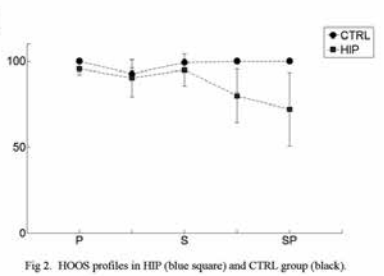


Fig 2. HOOS profiles in HIP (blue square) and CTRL group (black).

DISCUSSION & CONCLUSIONS

Motion patterns during gait seemed to be negatively affected in subjects with hip implant, even after the rehabilitation program was completed and even though the HOOS profiles indicated a relative good hip function.

REFERENCES

Favre J., Jolles B.M, Siegrist O., Aminian K., Quaternion-based fusion of gyroscopes and accelerometers to impprove 3D angle measurement, Electronic Letters, 2006,42(11)

GAIT AND CLINICAL OUTCOMES IN PATIENTS WITH SEVERE KNEE OSTEOARTHRITIS: A MULTIVARIATE APPROACH

Yoshimasa Sagawa Jr[1, 2], Stéphane Armand[1, 2], Anne Lubbeke-Wolf[2], Pierre Hoffmeyer[2], Suva Domizio[2], Katia Turcot[1, 2]

[1]Geneva University Hospitals and Geneva University, Willy Taillard Laboratory of Kinesiology, Geneva, Switzerland
[2]Geneva University Hospitals, Division of Orthopaedics and Trauma Surgery, Geneva, Switzerland

INTRODUCTION

Joint malalignment and gait deviations have been identified as important outcomes related to knee OA[1]. The relation between these outcomes and their evolution may be different between patients and challenging to interpret[2]. To understand the gait of patients with knee OA, a multivariate approach could be used. The aims of this study are to determine which gait parameters are best adapted to discriminate patients with knee OA, to discover if different gait profiles exist and to determine associations among gait outcomes and joint malalignment.

PATIENTS/MATERIALS and METHODS

Ninety patients with knee OA and scheduled for a total knee arthroplasty (TKA) were included in this study. Twenty six elderly subjects were recruited as the control group. The hip-knee-ankle (HKA) angle, as an outcome of knee alignment, was assessed by full-limb radiography. The gait analysis was performed using a motion analysis system and force plates. Seventeen parameters were chose according to the literature in knee OA. The gait parameters were coded and normalized using fuzzy functions related to *low, average and high* modalities. The multiple correspondence analysis (MCA), a multivariate technique, was used to produce a simplified representation of the dataset information[3]. When relevant information was obtained from MCA, analysis of variances were performed to confirm differences.

RESULTS

MCA highlighted a correspondence among 4 parameters: stride length, speed, knee flexion and hip flexion. MCA also highlighted a correspondence among 2 other parameters: thorax obliquity and knee adductor moment. Four knee OA gait profiles were highlighted: A, B, C and D. Comparing A with control group, excepted for the knee flexion range, there is no significant difference for all gait parameters. Comparing B with control group, excepted for the knee flexion range there is no significant difference for the spatial-temporal and sagittal parameters. However, B has significant more thorax obliquity and knee adductor moment than the control group. Compared to the control group, C presents significant reductions of the spatio-temporal and sagittal parameters. C has no significant thorax obliquity, but it has a significant less knee adductor moment compared to the control group. Compared to the control group, D has significant reductions of the spatio-temporal and sagittal parameters. D has a more important thorax obliquity, but no significant difference for the knee adductor moment compared to the control group. For the HKA angle, there is a significant difference between the A-C profiles (patients with normal to valgus alignments) and the B-D profiles (patients with varus alignments).

DISCUSSION & CONCLUSIONS

We highlighted 6 gait parameters which most contribute to the variance of our MCA and their main correspondences. These relevant parameters could be considered for the discrimination of gait deviations in patients with knee OA. They could be used to simplify gait interpretation of this population. Despite patients have severe knee OA and will be submitted to TKA, 4 gait profiles were observed and associated with knee malalignment. Patients with varus profiles increase thorax obliquity and reduce forward displacement whereas valgus profiles may only reduce forward displacement to manage knee OA evolution.

REFERENCES

[1] Franklin P. & Ayers D. *Clin Orthop Relat Res*. 466:2597-604, 2008. [2]. Astephen J. & Deluzio K. *Clin Biomech*. 20:209-17, 2005. [3]. Greenacre M. New York: Academic Press. 1984.

INFLUENCE OF ACETABULAR CUP POSITIONING ON MUSCLE ACTIVATION AND JOINT REACTION FORCES DURING DAILY ACTIVITES

Amir A Al-Munajjed[1], Søren Tørholm[2], Tim Weber[3], Arne Kiis[2] and John Rasmussen[4]

[1]AnyBody Technology, Aalborg, Denmark
[2]AnyBody Technology, Aalborg, Denmark
[3]University of Applied Sciences Regensburg, Department of Mechanical Engineering, Regensburg, Germany
[4]Aalborg University, Department of Mechanical Engineering, Aalborg, Denmark

INTRODUCTION

The importance of correct implant positioning has been proven previously as clinical complications arise after mal positioning of Total Hip Replacements. The objective of this study was to investigate the effect of implant position in a patient specific model on Joint Reaction Forces, Muscle Forces and Muscle Activations to predict correct implant position for surgery.

PATIENTS/MATERIALS and METHODS

The AnyBody Modeling System was used to compute the in-vivo muscle and joint reaction forces of a musculoskeletal model [1]. The full body model used in this study consistsing of more than 1000 individual muscle branches in total has been used previously by Mellon et al. [2] for Hip Surgery cases among others. In a Gait Lab an adult of 1.75 m and 75 kg has been recorded during Gait and several other daily activities. A virtual surgery of a Total Hip replacement has been performed varying the implant position of the acetabular cup. Joint Reaction Forces, individual Muscle Forces and Activations have been calculated and compared between the various implant positions, Figure1.

RESULTS

Joint Reaction Forces, but also Muscle Activation change significantly, when varying the implant position, i.e. an increase of the JRF of 80% could be seen by having a 2cm cranial offset of the acetabular cup position, Figure1.

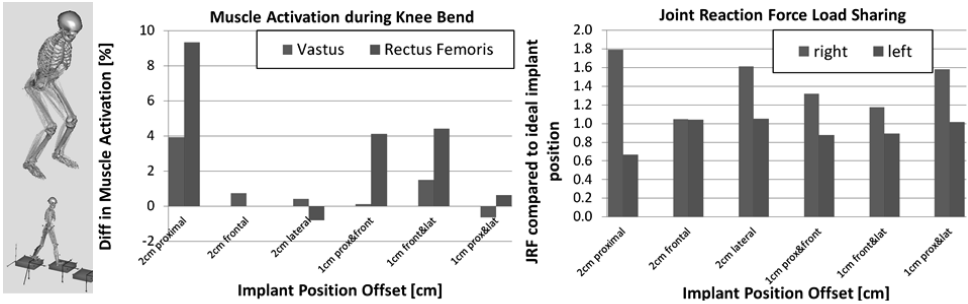


Figure1: Screenshots of the Model during a Kneebend and Gait activity. Muscle Activation and Joint Reaction Forces during the Kneebend with various offsets.

DISCUSSION & CONCLUSIONS

Several changes in Muscle Activations leading to different Joint Reaction Forces have been seen in this study, This may lead to different motion patterns in patients after Hip Surgery which might be related to clinical complications such as high wear rates.

REFERENCES

[1] Rasmussen, J. et al. Journal of Biomechanics, 34(3), 409-415, 2001.

[2] Mellon, S. et al. Proceedings of the ORS 2012.

PERSISTENT DIMINISHED JOINT FUNCTION FOLLOWING ANKLE FRACTURE - A RISK FACTOR FOR POSTTRAUMATIC OSTEOARTHRITIS?

Sebastian I. Wolf[1], Erich Lessl[1], Sebastian Müller[1], Gerhard Schmidmaier[1] and Thomas Dreher[1]

[1]Heidelberg University Clinics, Department for Orthopedics and Trauma Surgery, Heidelberg, Germany

INTRODUCTION

Ankle fracture is commonly treated by ORIF (open reduction and internal fixation) [1], which is typically followed by a postsurgical treatment using soft casting and limited weight bearing. Full weight bearing commonly is allowed after a six week period after surgery. However, it remains unclear how immobilization affects limb and foot biomechanics and how these develop. In many cases recovery takes longer and early osteoarthritis of the ankle might correlate with the ankle trauma and quality of reconstruction [2] but also with immobilization. Aim of this study was therefore to investigate the postsurgical limb and foot kinematics to evaluate possible remaining malfunctions.

PATIENTS/MATERIALS and METHODS

Nine weeks (E1) after unilateral ankle fracture and ORIF (Fig. 1) 16 adult patients (51.0±15.1yrs) were recruited for 3D gait analysis in combination with a foot analysis according to the Heidelberg foot measurement method [3]. All patients were re-evaluated 26 weeks after trauma (E2) using the same standardized protocol (reference: 14 age matched healthy controls; age 51.5±12.0yrs). ROM sagittal kinematics, kinetics and foot parameters were evaluated for the involved and the sound side as well as for the norm group. T-Tests were performed between groups and between examinations.

RESULTS

Nine weeks after trauma, patients still reduced the load in the involved side. Naturally the gait pattern differed to normal. 26 weeks after surgery all patients walked without noticeable limitation and without pain. However, the instrumented gait and foot analysis reveals that the kinematics is not fully recovered as many parameters remain significantly different to normal and to the sound side (Table 1). Moments and powers are still reduced up to 50%.

		E1		E2		p-value	p-value	p-value	p-value
ROM	Norm	sound	involved	sound	involved	Inv E1-Norm	Inv E2-Norm	sound E1-Norm	sound E2-Norm
Pelvis	2,7	4,7	4,8	2,8	2,8	0,005	0,880	0,005	0,716
Hip	44,8	39,5	35,4	42,1	42,3	0,000	0,078	0,001	0,088
Knee	56,9	49,7	50,7	53,0	52,9	0,000	0,003	0,000	0,005
Ankle	35,8	30,2	22,2	34,9	28,2	0,000	0,001	0,022	0,696
TibioTalar	23,1	19,1	15,0	22,8	17,9	0,000	0,001	0,015	0,840
SubtalarEversion	10,5	8,5	6,7	10,7	9,1	0,000	0,064	0,006	0,770
Forefoot/AnkleSupin	12,6	11,7	9,4	12,8	10,2	0,001	0,009	0,342	0,875
MedialArch	17,9	16,9	11,9	18,3	15,3	0,000	0,009	0,319	0,687
Hallux	50,2	43,1	33,3	48,0	44,3	0,000	0,016	0,002	0,315
Max	Norm	sound	involved	sound	involved	Inv E1-Norm	Inv E2-Norm	sound E1-Norm	sound E2-Norm
HipMoment	1,0	0,6	0,5	0,7	0,7	0,000	0,002	0,000	0,003
KneeMoment	0,5	0,2	0,3	0,3	0,3	0,000	0,000	0,000	0,000
AnkleMoment	1,6	1,4	0,9	1,4	1,3	0,000	0,000	0,000	0,001
HipPower	1,1	0,7	0,6	0,9	0,9	0,005	0,453	0,044	0,238
KneePower	0,7	0,4	0,3	0,4	0,5	0,000	0,043	0,001	0,009
AnklePower	4,5	2,7	1,2	3,5	2,8	0,000	0,000	0,000	0,001
Min	Norm	sound	involved	sound	involved	Inv E1-Norm	Inv E2-Norm	sound E1-Norm	sound E2-Norm
DorsiPlanFlexMoment	-0,2	-0,1	-0,1	-0,1	-0,2	0,042	0,243	0,004	0,009
KneeFlexExtMoment	-0,4	-0,4	-0,3	-0,3	-0,4	0,003	0,071	0,331	0,067
HipFlexExtMoment	-0,8	-0,7	-0,6	-0,8	-0,8	0,008	0,586	0,324	0,890

Tab.1: Average joint kinematics and kinetics 9 and 26 weeks post surgery Fig.1: Osteosynthesis after ankle fracture

DISCUSSION & CONCLUSIONS

In contrast to the clinical appearance, the majority of the patients show significant and relevant differences in foot kinematics and joint kinetics 6 months after surgery. This remaining malfunction may trigger the development of posttraumatic osteoarthritis, of which pathogenesis is not yet fully understood. These findings implicate that postoperative rehabilitation programs should consider an extended physical therapy in order to achieve physiologic function of the involved and compensating joints.

REFERENCES

[1] Day GA et al (2001): *Foot Ankle Int* 22:102–106. [2] Stufkens SA et al (2010): *Injury* 42:119–127.
[3] Simon J et al (2006): *Gait Posture* 23:411–424.

EFFECTIVENESS OF A FALL-PREVENTION TRAINING PROGRAM FOR PERSONS WITH LOWER EXTREMITY AMPUTATIONS: INITIAL RESULTS

Marilynn Wyatt, PT, MA[1], Pinata Sessoms, PhD[2], Mark Grabiner, PhD[3], Trevor Kingsbury, MA[1], Nancy Thesing, MS[1], Jordan Sturdy, BSE[2], Birgit Unfried, MA[1] and Kenton Kaufman, PhD[4]

[1]Naval Medical Center San Diego, San Diego, USA
[2]Naval Health Research Center, San Diego, USA
[3]University of Illinois, Chicago, USA
[4]Mayo Clinic, Rochester, USA

INTRODUCTION

The global war on terrorism has resulted in many warfighters sustaining lower extremity injuries including amputations. The key factors that limit the ability of patients with amputations to achieve maximum functional capabilities are falls and fear of falling. This research program was designed to rehabilitate lower extremity amputees to increase trust in their prosthesis and reduce falls by using a novel training method.

PATIENTS/MATERIALS and METHODS

Four service members with unilateral traumatic transtibial amputations were recruited at the Naval Medical Center San Diego (NMCSD). A perturbation testing protocol was developed utilizing a Computer Assisted Rehabilitation Environment (CAREN). This immersive virtual environment contains a motion platform and instrumented dual belt treadmill. The testing protocol delivered a perturbation simulating a trip in the natural environment and was used as a pre-test and post-test assessment of the rehabilitative program. Select biomechanical data using motion analysis methods were collected and calculated to determine effectiveness of the subjects' ability to recover from these disturbances. The fall prevention training program utilized a microprocessor-controlled Active-Step treadmill (Simbex, Lebanon, NH) designed to deliver task specific training perturbations. Three types of perturbations were used during six, 30 minute training sessions: static and static walk, during which the belt moved while the patient was standing still and to which the patient responded with one or multiple forward steps, respectively; and eTRIP perturbations, during which the perturbation was delivered at a random time while the subject was walking and required the subject to recover with multiple forward steps.

RESULTS

These preliminary data report on four male subjects, 24.3±2.1 years of age, who had been walking without an assistive device for 7.1±1.7 months. After participating in the fall prevention program, all subjects successfully avoided falling during the post-training perturbation test. The mean maximum trunk flexion angle from pre to post-test improved (38°±7° vs. 25°±7° on prosthetic limb perturbation; 32°±13° vs. 20°±3° on non-prosthetic limb perturbation) and trunk velocities at time of recovery step also improved. Questionnaire responses indicated improved reaction times, increased confidence and heightened awareness of their ability to recover from a stumble or trip in the community.

DISCUSSION & CONCLUSIONS

This novel rehabilitation method uses an innovative treadmill training method aimed at increasing the ability of the subjects with amputations to rely on their prostheses during challenging perturbations and thus improving their functional capabilities. This type of training has been shown to reduce falls in older adults [1]. The preliminary results indicate that this rehabilitation method will also be effective for those with amputations by increasing their ability to recover from a major perturbation as well as their functional performance.

REFERENCES

1. Owings TM, et al. Mechanisms of failed recovery following postural perturbations on a motorized treadmill mimic those associated with an actual forward trip, Clinical Biomechanics, 16:813-819, 2001.

FUNDING**:** DoD Grant No. DM090896; The Navy Bureau of Medicine and Surgery, Wounded Ill and Injured

Views in the article are those of the authors and not of the DoN, DoD, or the US Government.

EVALUATION OF GAIT PARAMETERS AND MECHANICAL WORK ON PATIENTS WITH LOWER EXTREMITY AMPUTATIONS

Nancy A Thesing, MS[1], Trevor Kingsbury, MA[1] and Marilynn P Wyatt, PT, MA[1]

[1]Naval Medical Center San Diego, C5 Gait Analysis Lab, San Diego, United States of America

INTRODUCTION

Due to improved body armor and medical techniques, the rate of war-related amputations experienced by military personnel is now twice that of prior wars[1]. Previous research has examined amputee gait, but information on bilateral trans-femoral amputees as a group is lacking. Therefore, the aim of this study was to compare gait parameters and mechanical work of subjects with bilateral trans-femoral (BTF) amputations to those with unilateral trans-tibial (UTT) amputations, unilateral trans-femoral (UTF) amputations, and able-bodied controls.

PATIENTS/MATERIALS and METHODS

At Naval Medical Center San Diego, a retrospective review was conducted of active duty military members who had undergone a BTF, UTT, or UTF amputation due to trauma and had been walking unassisted for at least three months. All subjects were male and matched for age (25.6±4.0yrs), height (176.9±5.5cm), and weight (82.1±13.6kg), resulting in groups of 14 UTTs, 9 UTFs, 9 BTFs, and 11 controls. Subjects wore their customized prosthesis(es) and walked at their self-selected pace as three dimensional gait data were collected with a 12-camera Motion Analysis Corporation (MAC) system (Motion Analysis Corp., Santa Rosa,CA) and four, floor-embedded AMTI force plates (AMTI, Watertown, MA). Trials were processed with Cortex (MAC) and OrthoTrak (MAC) software. Variables examined included gait velocity, cadence, stride length, step width, and mechanical work. Visual3D (C-Motion Inc., Germantown, MD) was used to calculate total mechanical work as the sum of the potential, translational, and rotational energies of each body segment, integrated per stride length for both lower limbs and normalized per stride and body mass (Joules/kg*m).

RESULTS

For each variable of interest, a 4 (condition) x 1 (dependent variable) ANOVA with alpha= 0.05 was run to detect significant differences. Age, height, and weight were not statistically different across groups, but post-hoc analyses using Bonferroni corrections showed the BTF group had significantly ($p<0.05$) greater mechanical work output and significantly ($p<0.05$) lower velocity, cadence, and stride length compared to the UTTs, UTFs, and controls. Step width post-hoc analysis using Games-Howell corrections found BTFs had a wider step width ($p<0.05$) than UTTs and controls but not UTFs. Linear regressions between mechanical work and velocity ($R^2=0.91$), cadence ($R^2=0.70$), step width ($R^2=0.46$), and residual limb length ($R^2=0.29$) were also performed.

DISCUSSION & CONCLUSIONS

In summary, the BTF group had a significantly slower walking speed (0.95±0.12m/sec), lower cadence (95.45±4.90steps/min), shorter stride length (119.52±11.67cm), and larger mechanical work output (11.12±1.17J/Kg*m) as compared to the UTT, UTF, and control groups. BTFs also had a wider step width (22.19±6.13cm) than UTTs and controls. The linear regression analysis showed slower walking speeds and lower cadences require higher mechanical work outputs. This is supported by the fact that the BTFs who had slower gait characteristics used approximately 45% more work per meter than the able bodied controls, 51% more than UTTs, and 35% more than UTFs. Although, no significant differences were found between UTFs, UTTs, and the controls, additional subjects could provide more power in order to detect differences across these groups.

REFERENCES

[1] Robbins CB, Vreeman DJ, Sothmann MS, et al: A review of the long-term health outcomes associated with war-related amputation. Mil.med. 174, 6-588 (2009).

Views in the article are those of the authors and not of the DoN, DoD, or the US Government.

THE SAGITTAL GROUND REACTION FORCE DISTANCE TO KNEE CENTER REFLECTS KNEE FLEXION MOMENT DURING GAIT IN TRANS-TIBIAL AMPUTEES

Christian Beyaert[1, 2], Julia Facione[1, 3], Constance Billon-Grumillier[1], Noël Martinet[1], Jean Paysant[1]

[1]Institut Régional de Réadaptation, Laboratoire d'analyse du mouvement, Nancy, France
[2]Université de Lorraine, Laboratoire de Physiologie, Vandoeuvre-lès-Nancy, France
[3]Ministère de la Défense, Hôpital d'Instruction des Armées Legouest, Metz, France

INTRODUCTION

In unilateral trans-tibial amputees (TTA), we previously reported compensatory mechanism involving the knee joint of the intact limb during gait 1. External maximal knee flexion moment, occurring at maximal knee flexion during stance phase, was significantly higher in intact limbs compared to prosthetic and control limbs. In intact limbs, this variable had significantly higher value in induced internal rotation prosthetic misalignment than in initial alignment suggesting a compensatory mechanism. External maximal knee flexion moment equals the sagittal component of ground reaction force (sGRF) times its sagittal perpendicular distance to the knee center in the knee joint coordinate system. We hypothesized that in this previous study maximal knee flexion moment alteration was mainly related to sGRF-knee distance alteration.

PATIENTS/MATERIALS and METHODS

Three-dimensional gait analysis had been conducted in 15 healthy subjects and 17 TTA walking at self-selected speed in three conditions of prosthetic alignment: initial alignment (IA); initial alignment altered either by 6° of internal rotation (IR) or by 6° of external rotation (ER) applied on the pylon. At maximal knee flexion, maximal knee flexion moment, sGRF and sGRF-knee distance were averaged on three gait cycles per condition and compared.

RESULTS

Patients reported best comfort of gait in IA condition and discomfort mainly in IR condition. Walking speed and stride length did not differ among conditions. In intact limbs maximal flexion moment, sGRF, sGRF-knee distance and maximal knee flexion were all significantly higher than in prosthetic limbs among the 3 conditions. In intact limbs, only maximal flexion moment and sGRF-knee distance had significant higher values in IR compared to IA condition (0.63 vs. 0.54 Nm/kg and 6.0 vs. 5.2 % of leg length, respectively). Maximal knee flexion moment was highly correlated to sGRF-knee distance (R^2 = 0.97 in prosthetic limbs, 0.95 in intact limbs and 0.96 in control limbs) but mildly to moderately correlated to sGRF (R^2 = 0.16 in prosthetic limbs, 0.52 in intact limbs and 0.19 in control limbs).

DISCUSSION & CONCLUSIONS

External maximal knee flexion moment was highly correlated to sGRF-knee distance in both TTA and controls. Compensatory mechanism to prosthetic misalignment involved knee dynamics in intact limbs in TTA. Real time display of the GRF vector overlaid on sagittal 2D video images may be a simple and useful tool to adjust prosthetic alignment. In particular, reducing the asymmetry between prosthetic and intact limbs of the GRF trajectory with reference to the knee joint may be of interest.

REFERENCES

[1] Beyaert C, Grumillier C, Martinet N, Paysant J, André JM. Compensatory mechanism involving the knee joint of the intact limb during gait in unilateral below-knee amputees. Gait Posture 2008; 28(2): 278-284

BIOMECHANICAL TESTING OF A SPINAL ALIGNMENT CUSHION ('ROPHI' CUSHION) IN ADULTS WITH LOWER BACK PAIN.

Ambreen Chohan[1], Katherine Payne[1], James Selfe[1] and Jim Richards[1]

[1]University of Central Lancashire, Allied Health Research Unit, School of Sport, Tourism & the Outdoors, Preston, United Kingdom

INTRODUCTION

Back pain has become a worldwide problem and excessive, repetitive rotation has been shown to cause tissue damage [1]. A sleeping posture similar to the foetal position has been suggested to limit unnecessary rotation of the lumbar spine [2]. The Rophi™ Cushion attempts to improve spinal alignment and sleeping posture. This study assesses the biomechanical alignment and subjective experience of pain and comfort when using the Rophi™ cushion in participants with simple mechanical lower back pain (LBP).

PATIENTS/MATERIALS and METHODS

Fifteen participants (aged 44 ± 9.7 years) with simple mechanical LBP were recruited using the Red Flags screening questionnaire[3].Ten Qualisys™ Oqus cameras recorded movement of the thorax and lower limbs using the six degrees of freedom CAST technique [4] and a multi-segment spine model, whilst participants lay in a semi-foetal position, pre intervention. The Pain and Comfort During SleepAssessment was carried out Pre/Post a one week intervention period with the Rophi™ cushion [5].

RESULTS

Kinematic results show the main significant difference in joint angles occurred at the hip in all three planes, and between the lower lumbar region and the pelvis in the coronal plane. Subjective experience showed a reduction in the number of days with poor sleep quality and a significant reduction in frequency and intensity of lower back pain and stiffness when waking. The Rophi™ Cushion received 100% positive feedback with regards to it's comfort and benefit predominantly being skewed towards "excellent comfort" and "extremely beneficial"

DISCUSSION & CONCLUSIONS

Through repositioning of the hips and lower lumbar spine, overall it appears the individual is moved towards a more neutral position when using the Rophi™ cushion and a one week intervention shows a significant improvement in lower back pain on waking. The cushion appears to allow a more sustainable sleeping posture by decreasing pressure and increasing the contact area at the knee. Has an overall distinct benefit for those suffering with simple mechanical LBP. Improvement in pain and discomfort when sleeping may have further implications for other similar groups including pregnant women with LBP.

REFERENCES

[1] Frymoyer, J. W. & Cats-Baril, W. L. (1991). Orthopaedic Clinics of North America , 22 (2), 263-271.

[2] Gracovetsky, S.A.,1987) Physical Therapy 67, 549-553.

[3] Greenhalgh S & Selfe J (2010) Elsevier, Oxford,UK

[4] Cappozzo A, et al. (1995) Clinical Biomechanics. 10: 171-178.

[5] Jacobsen B, et al. (2010) Applied Ergonomics. 39:247-254.

DEVELOPEMENT OF A MARKER BASED METHODOLOGY FOR THE EVALUATION OF SPINE MOBILITY IN ANKYLOSING SPONDYLITIS.

Silvia Del Din[1], Zimi Sawacha[1], Roberta Guglielmin[2], Elena Carraro[2], Aristide R Gravina[2], Fabiola Spolaor[1], Stefano Masiero[2] and Claudio Cobelli[1]

[1]University of Padova, Department of Information Engineering, Padova, Italy
[2]University of Padova, Department of Rehabilitation, Padova, Italy

INTRODUCTION

Ankylosing Spondylitis (AS) is a chronic rheumatic disease that causes a rigid spine; the typical dorsal hyperkyphosis may induce a stooped position with consequent restriction in patients' daily living activities.Assessment of the severity of the spine khyphosis and lordosis involves measuring from radiographs the largest curvature of the spine, known as the Cobb angles; the method showed high variability, furthermore it implies the subject to perform a complete spine radiography [1]. The aim of this study was to develop and validate a method based on marker based motion capture to quantitatively and objectively assess the spine mobility and to compare the results with the clinical measurements.

PATIENTS/MATERIALS and METHODS

10 healthy subjects (mean age: 35±10 years, mean BMI: 23±2 Kg/m^2) were recruited. Subjects underwent a clinical examination of the spine: both thoracic kyphosis and lumbar lordosis were measured by means of a pocket compass needle goniometer[2]. Six BTS motion capture system cameras (120Hz) were used to collect three dimensional data. A new protocol was adopted; 7 markers were placed in correspondence of the spinous process of vertebras C7, T3, T6, T9, T12, L3, and S1. The subjects were asked to perform 3 antero-posterior and medio-lateral flexion extension of the spine, then the position of all the missing vertebras from C7 to S1was reconstructed by means of an algorithm based on the interpolation of the data. In order to evaluate the clinical kyphosis and lordosis and the Cobb Angles between each pair of vertebras, an algorithm based on the evaluation of the tangents to the spine in correspondence of each vertebras was adopted. Intra-subjects validity and reliability of the method against the clinical measurements was conducted by 3 clinicians performing markers placement on a 26 years old subject (BMI: 22.15). Inter-subject repeatability assessment was performed by a clinicians placing the markers on the same subject for 3 trials. Pearson correlation coefficients were evaluated between the results obtained from intra-subjects and inter-subject repeatability analysis (Matlab Version 7.10).

RESULTS

The normative bands for each couple of vertebras together with the kyphosis (mean value: 46°±13°) and lordosis (mean value: 34°±18°) were evaluated. Intra-subjects repeatability showed a nice correlation ($0.94 \leq R \leq 0.97$), inter-subject validation correlation coefficients ranged from 0.95 to 0.97.

DISCUSSION & CONCLUSIONS

Our preliminary results indicate both the feasibility and reliability of methodology presented herein. Thus suggesting the possibility of performing a fast, objective and precise complete evaluation of spine mobility before and after rehabilitation in AS. This could be a valid support in planning ad hoc rehabilitation treatments.

REFERENCES

[1] Delorme S et al.: Assessment of the 3D Reconstruction and High-Resolution Geometrical Modeling of the Human Skeletal Trunk From 2D Radiographic Images. IEEE TRANS ON BIOM ENG. 2003, 50: 989-98.

[2] Masiero S et al.: Rehabilitation treatment in patients with ankylosing spondylitis stabilized with tumor necrosis factor inhibitor therapy. A randomized controlled trial. J Rheumatol. 2011, 38(7):1335-42.

IMPACT OF PHYSICAL EFFORT AND PAIN ON GAIT KINEMATICS PARAMETERS IN PATIENTS WITH LUMBAR SPINAL STENOSIS.

Silvio A Garbelotti Jr.[1], Paulo RG Lucareli[2], Wagner Godoy[3], Milena B Bernal[3], Amâncio Ramalho Jr.[3] and Julia MD Greve[4]

[1]University of São Paulo , Department of Experimental Physiopathology, São Paulo, Brazil
[2]Albert Einstein Hospital , Laboratory of Study of the Movement, São Paulo, Brazil
[3]Albert Einstein Hospital, Laboratory of Study of the Movement, São Paulo, Brazil
[4]University of São Paulo, Department of Experimental Physiopathology, São Paulo, Brazil

INTRODUCTION

The spinal stenosis term is based on the fact that a minimum space of the spinal canal is necessary for normal functioning of the nervous structures, and when this space becomes narrow, results in nerve compression symptoms such as pain, numbness, weakness and neurogenic claudication, which increase with stress and decreases with rest. The aim of this study is evaluate the impact of physical effort and pain in the functionality of gait in patients with lumbar stenosis in the periods before and after physical activity.

PATIENTS/MATERIALS and METHODS

Ten subjects were evaluated with diagnostic of lumbar stenosis with a mean age of 76.4 (10.1) years. The Vicon MX 40 system was used for the data acquisition during gait kinematic which consists of 10 infrared cameras (2000 fps). The exam consisted of three phases: 1) Capture of six gait cycles after a rest period without pain or symptoms; 2) Walkontreadmillfor a maximumof20 minutesorforced interruptionby the effectofpainorfatigue; 3) New capture of other 6 gait cycles was performed immediately after the exercise on the treadmill. From these data, the temporal spatial variables, the gait deviation index and the angular variation of the trunk were extracted and analyzed individually and then compared to the pain perception of each patient obtained by visual analogue scale.

RESULTS

We observed significant decrease in time of single support of 32.1 (4.7) to 31.4 (4.1) ($p = 0.023$) and balance of 32.0 (5.5) to 31.5 (4.3) $p = 0.048$, and an increase in double support of 35.9 (9.2) to 37.3 (8.1) (Wilcoxon; $p=0.012$). In the comparison between the GDI pre and post physical activity, a functional decrease of 78.1 (20.1) to 76.3 (17.7) at the left side and of 76.8 (18.4) to 75.2 (16.8) at the right side were found, but no significant difference were found between patients (Wilcoxon; $p>0.05$). On the other hand the trunk tilt average increased significantly from 11.9 (10.0) to 12.9 (10.4) (Wilcoxon; $p=0.019$). The perception of pain increased from 0.7 (1.2) to 4.0 (3.4) (Wilcoxon; $p=0.011$) and, when correlated with the kinematic data based on the negative correlation value (Spearman, -.812; $p=0.05$) on both sides, the results show significant correlation with pain score after physical activity.

DISCUSSION & CONCLUSIONS

The significant variations of pain and time of the gait cycle periods pre-and post-exercise suggest that subjects were able to develop a strategy to compensate for the changing balance[1,2,3]. And the increase of the trunk tilt suggests an effective control strategy to ease the pain [4].

REFERENCES

[1] Bacchini M, Rovacchi C, Rossi M. [Abstracts 2007 SIAMOC]. Gait Post. 2008 August;28(Suppl1):S1-S2. [2] Haig AJ, Tong HC, Yamakawa KS, Parres C, Quint DJ, Chiodo A, Miner JA, Phalke VC, Hoff JT, Geisser ME. Spine. 2006 Dec 1;31(25):2950-7. [3]Tong HC; Haig AJ; Geisser ME; Yamakawa KS; Miner JA. Gerontology. 2007;53(2):111-5. [4] Papadakis NC, Christakis DG, Tzagarakis GN, Chlouverakis GI, Kampanis NA, Stergiopoulos KN, Katonis PG. Physiol Meas 2009a;30:1171–1186.

KINESIOLOGICAL ANALYSIS OF MOVEMENT OF THE HUMAN LUMBAR SPINE

Małgorzata B. Ogurkowska[1] and Jacek Lewandowski[2]

[1]University School of Physical Education , Department of Biomechanics, Poznan, Poland
[2]University School of Physical Education, Department of Motor System Rehabilitation, Poznań, Poland

INTRODUCTION

Modern medical knowledge concerning spine pathology takes into account an exceptional variety of interpretation of causes, symptoms and methods of assessment, including healing methods. Different experts, depending on medical specialization, that they represent, have various judgments of reasons of pains derivative from the spine and they use different healing methods, characteristic for their own specializations. This proclaims the great kinesiological complexity of spine. In this range the medical environment has been reinforced by scientists from area of technology. The objective of this paper is a three – dimensional modeling of vertebra segment (L4-L5), which can be used in numerical simulation of surgery, analysis of spinal equilibrium and stability.

PATIENTS/MATERIALS and METHODS

Research material consisted of the lumbar section L4 - L5 of 20 men (21 to 33 years old) .The research method consists in the analysis of tomographic images obtained as a result of tests carried out with the use of a Computer Tomograph (CT).The first step to provide three-dimensional kinesiological analysis of the human lumbar spine is prepare the valuable geometrical - CAD model constructed using the data taken from computer tomography (CT). Next, the mechanical properties of tissues structure as well as the system of loading are applied and computations are performed by Finite Element Method (FEM)

RESULTS

The presented model was validated for compression, two bendings in vertical plains, and torsion [1]. The boundary conditions and values of the forces, were adapted based on the published data [1-2]. On the basis of the gained results, it was possible to verify the validity and quality of the model definition. The axial displacement and disc bulge for compression, and rotation for bending and an axial rotation for torsion were compared with the values taken from literature [1]. The six loading cases with the unit loads/moments were applied to the spinal segment to calculate required coefficients of the stiffness matrix. The loads were applied to the reference point which couples all points on upper surface of the vertebral body; the bottom surface of the vertebral body was constrained against any movement.

DISCUSSION & CONCLUSIONS

The Finite Element Method (FEM) is successfully applied into the simulations of kinesiological systems [2]. It is proved [2] that failure or prediction of changes in biomechanical parameters and remodeling of the motion spinal segment are related to the stress and strain fields in the tissue and may be computed using FEM. To estimate the stress and strain fields the computational models have to incorporate experimentally determined material properties, realistic geometry and appropriate boundary conditions. Practical application of FEM in individual biomechanical sets will be possible when the actual basic data describing an individual's traits are provided. A method has been worked out which, thanks to the existing relation between the osseous tissue's mechanical properties and radiological density, uses the computer tomography to estimate the tissue’s rigidity

REFERENCES

[1] Adams M.A., *The Biomechanics of Back Pain*, Elsevier Science Limited, Churchill Livingstone, 2002.

[2] Ogurkowska M.B. *Are we able to support medical diagnosis or rehabilitation of human vertebrea by numerical simulation ?*, 15th Int. Conf. on Computer Methods in Mechanics, June 3-6, 2003, Gliwice, Poland.

DEVELOPMENT OF LUMBAR SPINE MOBILITY IN HUMANS AGED 3-25 YEARS

Jacek Lewandowski[1] and Małgorzata B. Ogurkowska[2]

[1]University School of Physical Education, Department of Motor System Rehabilitation, Poznań, Poland
[2]University School of Physical Education, Department of Biomechanics, Poznań, Poland

INTRODUCTION

Range of segmental mobility of the spine is part of a standard clinical evaluation of musculoskeletal system. Study results differ significantly because of the diversity of measurement methods and equipment that are used. The study aim has been to show ontogenetic changeability of segmental mobility of the spine in the lumbar region and to define angular values of spinal mobility in relation to the sex and age of the study subjects.

PATIENTS/MATERIALS and METHODS

Study population comprised 24517 subjects (12161 females and 12356 males) aged 3 to 25 years. To illustrate the tempo of developmental changes the study population was divided into age categories of one year interval, ie 23 such age groups were formed. Resistance electrogoniometry was used to measure spondylometric features. Reliability and comparability of the measurements of the lumbar spine range of motions were assessed.

RESULTS

High extra and intraclass correlation (ICC) values indicate acceptable consistency of the results. External integration coefficient equalled 0.84-0.96. It is noteworthy that the consistency between measurements is very good with intraclass correlation coefficient being in an excellent range of 0.88-0.98. The highest developmental ceiling is that of anteflexion and it is higher among males. Slightly lower values of gradients could be observed for extension and lateral flexion. Least developmentally advanced was bilateral axial rotation. Throughout the whole period of development the lumbar spine mobility is higher among males except for the constant level of axial rotation observed in both sexes.

DISCUSSION & CONCLUSIONS

Different rate of development could be observed in the lumbar spine segment mobility in different age groups. Based on the results a model of centile nets of ontogenetic changeability of segmental mobility of the spine in the lumbar region was constructed.

REFERENCES

[1] Biblia et al (2010) J.Spinal Disord Tech 23,(2) : 106-112

[2] Dvorak et al (1995) Eur Spine J 4: 18-23

[3] Intolo et al (2009) Man Ther 14,(6): 596-604

COMPARISON OF CERVICAL KINEMATICS BETWEEN PATIENTS WITH CERVICAL ARTIFICIAL DISC REPLACEMENT AND ANTERIOR CERVICAL DISCECTOMY AND FUSION FOR CERVICAL DISC HERNIATION

Jung Hwan Lee[1], June Ho Lee[2], Jin Sung Kim[2], Chan Sik Shim[2], Ewy Ryoung Jung[3] and Sang-Ho Lee[2]

[1]Wooridul spine hospital, Physical medicine and Rehabilitation, Seoul, South Korea
[2]Wooridul spine hospital, Neurosurgery, Seoul, South Korea
[3]Wooridul spine hospital, Orthopedic surgery, Seoul, South Korea

INTRODUCTION

Although anterior cervical discectomy and fusion(ACDF) is the one of effective treatment option for patients with cervical disc herniation, it limits cervical range of motion, which sometimes causes discomfort and leads to biomechanical stress at neighbouring segments. Whereas, cervical artificial disc replacement(ADR) is supposed to preserve cervical range of motion than ACDF. The biomechanical measurement is necessary to identify the advantage and clinical implication of ADR. However, there are scanty amount of literatures about this topic and these were assessed by static radiological method, which has no ability to identify three dimensional motions and coupling motions during motion of one axis. The purpose of this study is to compare the clinical parameters and cervical kinematics measured by three dimensional motion analysis between ACDF and ADR and to investigate the ability of ADR to maintain cervical motions.

PATIENTS/MATERIALS and METHODS

The patients who underwent ADR or ACDF for treating single level cervical disc herniation were recruited. The patients were evaluated by Visual analogue scale (VAS) and Korean version of Neck Disability Index (NDI, %) to assess pain degree and functional status. Cervical kinematics was assessed by three dimensional motion analysis in terms of sagittal, coronal, and horizontal planes. These evaluations were performed preoperatively and 1 month and 6 months after surgery.

RESULTS

The ACDF and ADR group revealed no significant difference in VAS, NDI, and cervical range of motion preoperatively. After surgery, both groups showed no significant difference in VAS and ODI. In motion analysis, significantly more range of motion was retained in flexion and extension in the ADR group than the ACDF group at 1 month and 6 months. There was no significant difference in lateral tilt and rotation angle. In terms of coupling motions, ADR group exhibited significantly more preserved sagittal plane motion during right and left rotation and also showed significantly more preserved coronal plane motion during right rotation than ACDF group at 1 month and 6 months. There was no significant difference in other coupling motions.

DISCUSSION & CONCLUSIONS

Three dimensional motion analysis was useful to assess cervical kinematics after surgery. It allowed us to measure not only main motions but also coupling motions in three planes respectively. ADR was more physiological surgical method than ACDF because ADR accomplished the more retained sagittal plane and more preserved coupling movements in sagittal and coronal planes during transverse rotation than ACDF.

REFERENCES

1) Puttlitz CM et al. *Spine* 2004;29:2809-14. 2) Sasso RC et al *J Spinal Disord Tech* 2008;21:19-22.

GAIT IMPAIRMENT IN CERVICAL SPONDYLOTIC MYELOPATHY: ANALYSIS OF MUSCLE ACTIVATION TIMING

Ailish Malone[1], Dara Meldrum[2], John Gleeson[3] and Ciaran Bolger[4]

[1]Beaumont Hospital, Physiotherapy Department, Dublin, Ireland
[2]Royal College of Surgeons in Ireland, School of Physiotherapy, Dublin, Ireland
[3]Royal College of Surgeons in Ireland, Department of Anatomy, Dublin, Ireland
[4]Beaumont Hospital, Department of Neurosurgery, Dublin, Ireland

INTRODUCTION

Gait impairment is a primary symptom of cervical spondylotic myelopathy (CSM). Analysis of the timing of muscle activation during gait, using surface electromyography (SEMG), can improve the understanding of a gait deficit. The aim of this study was to compare muscle activation timing during gait in people with untreated CSM and in age- and gender-matched healthy controls.

PATIENTS/MATERIALS and METHODS

Ethical approval was obtained from a hospital Ethics Committee. Sixteen people with untreated CSM were recruited consecutively from a neurosurgery clinic, and matched to healthy controls of the same age (± 5 years) and gender. Participants from both groups completed at least ten walking trials at comfortable gait speed along a 10-metre walkway. Healthy controls then completed a second set of ten walking trials at the same speed as the CSM participants to whom they were matched. SEMG signals were recorded during gait from rectus femoris, biceps femoris, tibialis anterior and medial gastrocnemius using standard electrode recording and placement procedures. Signals were processed using MATLAB® and the timing of activation was extracted using a previously validated reliable method [1]. The duration of activation for each muscle was expressed as a percentage of gait cycle time. Data for CSM participants and healthy controls were compared using paired t-tests.

RESULTS

The mean comfortable walking speed of CSM participants was 1.12 m/s, while healthy controls walked at a mean of 1.49 m/s. Comparing both groups at comfortable walking speed, CSM participants demonstrated significantly prolonged activation of rectus femoris (33% gait cycle duration compared to 22% in healthy controls, $p = 0.04$), biceps femoris (32% v 22%, $p = 0.001$) and tibialis anterior (42% v 30%, $p = 0.007$), but not medial gastrocnemius (32% v 29%, $p = 0.4$). Co-activation of rectus and biceps femoris was also prolonged in CSM (14% v 9%, $p = 0.04$). No differences were found in the co-activation time of tibialis anterior and medial gastrocnemius (7% v 4%, $p = 0.17$). The results of the matched speed analysis mirrored the findings at comfortable speed, with the same muscles showing statistically significant differences between CSM participants and controls.

DISCUSSION & CONCLUSIONS

This study was the first to identify and quantify abnormally prolonged duration of activation of the lower limb muscles as a feature of gait in CSM. The persistence of these findings at matched gait speed confirmed that these were features of abnormal neuromuscular control, and not a consequence of slower gait speed. Prolonged duration of activation may be a strategy to compensate for lack of stability or weakness of lower limb muscles during gait.

REFERENCES

[1] Malone A, Meldrum D, Gleeson J & Bolger C (2011). J Electromyogr Kinesiol, 21, 1004-1010

THE CHARACTERISTICS OF GAIT DISTURBANCE AND ITS RELATIONSHIP WITH POSTERIOR TIBIAL SOMATOSENSORY EVOKED POTENTIALS IN PATIENTS WITH CERVICAL MYELOPATHY

Jung Hwan Lee[1] and Sang-Ho Lee[2]

[1]Wooridul spine hospital, Physical medicine and Rehabilitation, Seoul, South Korea
[2]Wooridul spine hospital, Neurosurgery, Seoul, South Korea

INTRODUCTION

Many of patients with cervical myelopathy(CM) suffer from gait disturbance so that the assessment of walking ability and its restoration are one of main concerns. This study is to investigate the gait characteristics of CM and to assess the relationship between presence of abnormality of posterior tibial somatosensory evoked potentials(PTSEP) and gait parameters.

PATIENTS/MATERIALS and METHODS

The patients were recruited who had suffered from gait disturbance and were diagnosed as CM by cervical magnetic resonance image(MRI). All subjects underwent three dimensional gait analysis and PTSEP. Normal person were recruited as control groups and underwent gait analysis The CM patients were divided into two groups such as normal and abnormal SEP groups and two groups were compared as to presence of signal change in MRI and gait parameters.

RESULTS

CM groups revealed significantly decreased gait velocity, step length and stride length, as well as increased double support time. They showed significantly decreased maximal knee flexion angle in swing phase, the decreased plantarflexion angle at push off, and the increased maximal dorsiflexion angle at swing phase in comparison with control group. Abnormal SEP group demonstrated decreased gait velocity and cadence, decreased plantarflexion angle at push off and increased maximal dorsiflexion angle at swing phase in comparison with normal SEP group. There was no significant relationship between presence of SEP abnormality and signal change of MRI.

DISCUSSION & CONCLUSIONS

CM Patients with PTSEP abnormality showed gait characteristics of CM patients more prominently than those without PTSEP abnormality. These results supported that the gait deviation of CM was attributed to impaired proprioception of lower limbs and poor stability. Damage of the posterior columns by CM interrupted the delivery of information about joint position and movement and consequently often causes gait disturbance.

CM patients compensated stabilizing balance by decreasing gait velocity and step length as well as increasing step width and double support time. Step length was shortened by decreasing ankle plantarflexion at push off stage at the end of preswing in gait cycle. Decreased ankle plantarflexion at push off might lead to decreased knee flexion and increased ankle dorsiflexion at swing stage.

REFERENCES

1) Dennis GC, Dehkordi O, Millis RM et al. Somatosensory evoked potential, neurological examination and magnetic resonance imaging for assessment of cervical spinal cord decompression. Life Sci 2000: 66: 389-397.

2) Takayama H, Muratsu H, Doita M et al. Impaired joint proprioception in patients with cervical myelopathy. Spine (Phila Pa 1976) 2005: 30: 83-86.

3) Maezawa Y, Uchida K, Baba H. Gait analysis of spastic walking in patients with cervical compressive myelopathy. J Orthop Sci 2001: 6: 378-384.

A THOROUGH ANALYSIS OF THE COEFFICIENT OF MULTIPLE CORRELATION (CMC) SHOWS MULTIPLE PROBLEMS

Jo Røislien[1], Linda Rennie[2] and Arve Opheim[2]

[1]University of Oslo, Department of Biostatistics, Oslo, Norway
[2]Sunnaas Rehabilitation Hospital, Nesoddtangen, Norway

INTRODUCTION

The question of reliability is essential for any measurement method, and when investigating reliability of 3DGA kinematic curves the coefficient of multiple correlations (CMC) [1] is frequently used, despite the reports of methodological issues [2]. The aim of the current study was to perform a systematic evaluation of the CMC using stochastic simulations. The results are exemplified on an inter-rater reliability study of 3DGA data related to marker placement.

PATIENTS/MATERIALS and METHODS

Synthetic gait curves were generated from a stochastic model where amplitude, vertical offset and a possible horizontal shift due to random error and timing issues were included as stochastic variables. The model was used hierarchically. First a "true" curve for each subject was sampled; then curves from each of the different test situations, e.g. different tester teams, was sampled using this "true" curve as the mean. The CMC is a measure of similarity of waveforms, e.g. curve data [1], comparing multiple curves from several subjects across test situations, e.g. testers. The CMC was calculated based on the synthetic data with systematic variations in curve amplitude, frequency, vertical curve offset, and number of subjects and number of test situations. Confidence intervals were estimated using bootstrapping. Seven healthy adult volunteers gave written informed consent to take part in the accompanying inter-rater reliability study. The subjects were tested on two consecutive days by two different tester teams. 3DGA data was recorded during bare feet, level walking along a 10m walkway at self-selected comfortable walking speed, using six Vicon MX13 cameras, and the Plug-in-Gait model. For each subject, one left cycle from each test situation was selected, based on similarity in walking speed.

RESULTS

Joints with large amplitudes, i.e. above 15°, resulted in CMC>0.9. High sampling frequencies, i.e. above 20 points per gait cycle, also resulted in CMC>0.9. Increasing offsets resulted in decreasing CMC values. For two test situations 20 subjects resulted in wider CIs for the CMC than five subjects on five test situations. In the inter-rater reliability study, the CMC calculations consistently broke down, i.e. could not be computed, for joints with a low amplitude. In curves with a visually apparent systematic vertical offset, the CMC was still approximately 0.9.

DISCUSSION & CONCLUSIONS

The CMC is sensitive to the amplitude of the curve, demonstrating how the signal-noise ratio is a problem issue. As the CMC does not adjust for the inter-gait-curve correlation between data points, higher sample frequency leads to high CMCs, merely due to high correlation between data in the calculations. The frequently used reliability design of two tester teams was demonstrated to show comparably high CIs. In conclusion, in our study the CMC did not show the statistical properties that are needed for it to be an overall measurement of curve similarity. Other methods than the CMC must be used to assess reliability of 3DGA data.

REFERENCES

[1] Kadaba MP, Ramakrishnan HK, Wootten ME, Gainey J, Gorton G, Cochran G V B. (1989) Repeatability of kinematic, kinetic, and electromyographic data in normal adult gait. Journal of Orthopaedic Research 7, 849-860.

[2] McGinley JL, Baker R, Wolfe R, Morris, ME. (2009) The reliability of three-dimensional kinematic gait measurements: A systematic review. Gait & Posture 29, 360-369.

DETERMINATION OF REACTION FORCES AND MOMENTS IN THE FOOT JOINTS USING MULTIBODY DYNAMICS AND FE ANALYSIS – A CLINICAL APPLICATION

Christian Wyss[1] and Reinald Brunner[1]

[1]Laboratory for Movement Analysis, University Children's Hospital Basel, University of Basel, Basel, Switzerland

INTRODUCTION

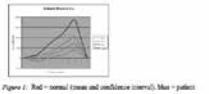
Daily routine does not allow determining joint reaction forces and moments or stress and strain in vivo. These data of mechanics, however, help understanding foot function and may guide treatment decision making. Finite element analysis (FE) offers one way to calculate the intra-articular forces and moments in the foot.

PATIENTS/MATERIALS and METHODS

A full 3D gait analysis was performed including one EMED SF pressure measurement platform. The "GaitLowerExtremity" model from the ANYBODY Repository AMMRV1.4.1 was used to determine the muscle forces of the lower leg during gait. The muscle forces from the ANYBODY model, the regional reaction forces from the EMED SF platform and the 3D kinematics were used as boundary conditions for the FE-model. A "standard foot model" was created from a CT scan of one healthy foot. This model was imported in ANSYS Workbench V.14.0 and scaled according to the subject's standard x-rays. For ethical reasons true normals were not available for reasons of irradiation. Thus 10 patients with moderate hallux valgus deformity were considered close to normals. Their data were analysed by this model using a multi body dynamic analysis with 100 load steps and taken as reference (normative) values. The data of one patient with hindfoot instability were analysed in respect of the normative data.

RESULTS

Mean and standard deviation of the reaction force and the reaction moment of every joint in the foot were calculated. The data from a patient with hindfoot instability were compared with the normal values (figure 1). The red curves show the mean and the confidence interval in x direction in the subtalar joint gained from the 10 patients. The blue curve represents the data of the patient. A deviation of more than one confidence interval from the normative values is considered significant. The analysis shows an increased load at the subtalar joint in this case. The mathematical principle described can be applied for every joint in the foot.



DISCUSSION & CONCLUSIONS

The combination of multibody dynamics and FE analysis enables to calculate moments in the various foot joints. In addition stress and strain can be estimated cutting free the bony segment of interest and applying the loads during motion from the multibody dynamics. It would have been preferable to use true normal data from healthy subjects but unfortunately this was not possibvle for ethical reasons. Thus the data closest to normal were used instead. The method can even be applied in daily routine. In the case of one patient with hindfoot instability an overload of the subtalar joint was demonstrated.

REFERENCES

1. Gefen AEA. Biomechanical Analysis of the Three-Dimensional Foot Structure During Gait: A Basic Tool for Clinical Applications. Transaction of ASME. 2000 Dec. 4;122:630–639.

2. Cheung JT-M, Zhang M, Leung AK-L, Fan Y-B. Three-dimensional finite element analysis of the foot during standing—a material sensitivity study. Journal of Biomechanics. 2005 May;38(5):1045–1054.

DO DIFFERENT METHODS OF HIP JOINT CENTRE LOCATION IMPACT ON KINETICS AND KINEMATICS IN OBESE ADULTS?

Ambreen Chohan[1], Paola Dey[2], Chris Sutton[3], Dominic Thewlis[4] and Jim Richards[1]

[1]University of Central Lancashire, Allied Health Research Unit, School of Sport, Tourism & the Outdoors, Preston, United Kingdom
[2]University of Central Lancashire, The Institute for Postgraduate Dental Education, Preston, United Kingdom
[3]University of Central Lancashire, School of Health, Preston, United Kingdom
[4]University of South Australia, School of Health Sciences, Adelaide, Australia

INTRODUCTION

Kinetics and kinematics at all weight bearing joints must be comprehensively measured in order to fully understand quality of movement and the impact of activity restriction in obesity. Difficulty in identifying anatomical landmarks at the pelvis and thigh affects the location of the Hip Joint Centre (HJC), particularly in obese subjects. Accurate estimation of the HJC is important not only in measurement of hip moments and adduction/abduction angles [1], but also because it determines varus/valgus deformity of the knee, which are key factors when evaluating knee pathologies. This study compares the relative bias and agreement between five methods of locating the HJC in obese and non-obese adults.

PATIENTS/MATERIALS and METHODS

8 obese subjects (BMI≥30) and 8 healthy age matched subjects (BMI= 20-24.9) were recruited to this study. The kinematics and kinetics of the lower limbs, pelvis and thorax were recorded using a ten-camera ProReflex movement analysis system at 100 Hz (Qualisys Medical, AB). Five models: one functional and four predictive were defined based on the different methods used to estimate the hip joint centre. These were: the functional method [2], and the predictive models described by Harrington et al. [3] Bell et al. [4] and two predictive methods derived from the conventional gait model (CGM) Davis et al. [5] (Helen Hayes and the Plug-in-Gait).

RESULTS

Significant differences in HJC location were found between the functional method and each predictive method for all participants as well as between the Harrington method and other predictive methods. There were significant differences in HJC location between the CGM methods in all planes ($p<0.01$) for both the obese and non-obese groups. Whilst knee ROM was similar in the sagittal and transverse planes, the true impact of the HJC location occurred in the coronal plane of the knee ($P\leq0.005$), possibly due to change in axes of the femur relative to the tibia, allowing planar cross-talk.

DISCUSSION & CONCLUSIONS

In obesity, movement range may be restricted and hence make it difficult to perform the movement required to calculate the “recommended” functional HJC. The alternative then lies in a predictive model that is unable to account for asymmetry and shows significant differences in both obese and non-obese groups. It is therefore vital to report the exact method used to allow data-sets to be comparable. Different methods of calculating the HJC, can cause changes in the reported of hip moments and adduction/abduction angles as well as varus/valgus deformity of the knee angle. Such measurements are of particular importance when reporting treatment of knee pathologies (i.e. medial compartment osteoarthritis) in both obese and non-obese groups.

REFERENCES

[1] Stagni R. et al., J Biomech. 33:1479-87, 2000.
[2] Schwartz M. et al., J Biomech. 38:107-16, 2005.
[3] Harrington ME et al. J Biomech. 40: 595-602, 2007.
[4] Bell A. et al., J Biomech. 23: 617-21, 1990.
[5] Davis RB. et al., Hum Mov Sci. 10: 575-87, 1991

EFFECTS OF A VIRTUAL REALITY ENVIRONMENT IN SELF-PACED TREADMILL WALKING

Jaap Harlaar[1], Lizeth Sloot[1] and Marjolein Van der Krogt[1]

[1]VU University Medical center, Rehabilitation Medicine, Amsterdam, Netherlands

INTRODUCTION

Walking on a treadmill is known to effect gait performance, resulting in a lower preferred walking speed, shorter step length, higher cadence, and slightly decreased joint range of motion [1, 2]. It is suggested that these differences might be caused by the imposed walking speed of the treadmill and the absence of optical flow (OF). A virtual reality environment (VRE) that is linked to the belt of the treadmill, will restore natural optical flow during walking. The purpose of this study was to evaluate the effect of adding a VRE to self-paced (SP) treadmill walking in healthy subjects. It was hypothesized that a VRE would restore the natural OF, and therefore increase comfortable walking speed on a treadmill.

PATIENTS/MATERIALS and METHODS

Eighteen healthy subjects (12 male, age 29±4) walked on a SP controlled dual-belt instrumented treadmill with and without a speed-matched virtual environment (Gait Real-time Analysis Interactive Lab (GRAIL), Motek Medical B.V, the Netherlands). The self-paced treadmill speed was regulated by a PD controller. The VRE (driven by the belt-speed) was based on a simple scene with an endless road.. After a habituation period subjects were asked to walk on their comfortable walking speed, and to maintain that for 3 minutes with and without a VRE, its order randomly chosen. During the last minute walking speed, stride time, stride length, and step width were calculated, using kinematics from a 3D optoelectronic system and the build-in forceplates. Besides parameter means over all strides also the variation over all strides was taken to reflect individual variability. The effect of adding a VRE was evaluated using paired t-tests with multiple comparison correction ($p < 0.05$).

RESULTS

The spatiotemporal data is given in the table below, with the mean and standard deviation averaged over left and right steps. Comfortable walking speed decreased by 4% when adding a VRE. This was also expressed in the stride length, while cadence remained unchanged. No other significant changes were seen.

	Parameter Means			**Mean Intra Subject Variation**		
Parameter	**SP_{VR}** *mean±std*	**SP** *mean±std*	**Effect** *p-value*	**SP_{VR}** *mean±std*	**SP** *mean±std*	**Effect** *p-value*
Walking speed (m/s)	**1.37**±0.12	**1.43**±0.13	**0.02**	0.067±0.009	0.070±0.009	0.05
Stride length (m)	**1.40**±0.10	**1.44**±0.10	**0.01**	0.081±0.023	0.081±0.027	0.70
Stride time (s)	1.08±0.06	1.08±0.06	0.42	0.023±0.023	0.021±0.008	0.84
Step width (cm)	1.2±0.006	1.2±0.006	0.73	0.006±0.002	0.006±0.001	0.34

DISCUSSION & CONCLUSIONS

Contrary to our hypothesis, adding an immersive VRE to a treadmill, will cause healthy subjects to slow down their comfortable walking speed. Apparently, restoring the OF by adding a VRE does not normalize a comfortable, i.e. self chosen, walking speed. In a study that used VRE by means of a helmet mounted display the same effect was seen: slower OFs induced faster walking speeds, and vice versa [3]. A unchanged amount of variability in spatiotemporal parameters was also found in a study that explored non linear effects [4]. Further studies should focus on what elements of treadmill versus overground walking are causal in the changed perception.

REFERENCES

[1] Riley *et al*., Gait and Posture 26 (2007) 17-24 [3] Lamontagne *et al*., J Neuroeng Rehabil. (2007) 4-22

[2] Matsas *et al*., Gait and Posture 11 (2000) 46-53 [4] Katsavelis *ea*, Nonlin. Dyn. Psy.Life Sci. (2010) 239-56

EXPERIMENTAL VALIDATION OF A SENSOR TO SEGMENT CALIBRATION PROCEDURE FOR MIMU BASED GAIT ANALYSIS

Eduardo Palermo[1], Stefano Rossi[1, 2], Fabrizio Patanè[1, 2], Maurizio Petrarca[2], Enrico Castelli[2], Paolo Cappa[1, 2]

[1]"Sapienza" University of Rome, Department of Mechanical and Aerospace Engineering, Rome, Italy
[2]"Bambino Gesù" Children's Hospital, Movement Analysis and Robotic Laboratory (MARLab) - Pediatric Neuro-Rehabilitation Division, Rome, Italy

INTRODUCTION

In the last years, a lot of works have been focused on the utilization of inertial sensors as Magnetic Inertial Measurement Units (MIMUs) in gait analysis. In order to obtain the lower limb joint angular kinematics, the estimation of each body segment orientation is needed. Each MIMU sensor is able to provide the orientation of its reference frame (SRF) with respect to a ground reference frame (GRF). Unfortunately, due to manufactory differences and magnetic field distortion problems [1], data provided by MIMU sensors nominally identical cannot be considered as referred to the same GRF [2]. Moreover, a sensor-to-segment calibration procedure is needed for the assessment of the relative rotation between SRF and the body segment reference frame (BRF). In literature, the proposed calibrations are not feasible in clinical practice, and are also not immune from prone to the effects induced by the difference among the GRFs. Purpose of the present study is the experimental validation of a functional calibration procedure [3], conveniently modified in order to take into account the GRF relative rotations. In this perspective the intra-subject repeatability (REP) and the accuracy (ACC) of the calibration have been evaluated by means of a comparison with an optoelectronic system.

PATIENTS/MATERIALS and METHODS

The calibration procedure was repeated ten times on one healthy subject and a gait analysis trial for over 50 strides was conducted. The right leg of the examined subject was instrumented with four MIMUs (Xsens Technologies, NL) placed on pelvis, thigh, shank and foot. Reflecting markers were placed on anatomical reference points of the subject and on each sensor. An optoelectronic system (OS) has been employed for the actual estimation of the relative rotation between sensor and body segment. Moreover, during the first phase of the calibration, the GRF relative rotations have also been measured. Both the repeatability and the accuracy of the procedure were computed in terms of offset and waveform distortion of the three lower limb joint angles during gait trial. Table 1 – Maximum values of accuracy and repeatability errors on the three lower limb joint angles.

Joint	Fl/Ex (°)		Ab/Ad (°)		In/Ex rot (°)	
	ACC	REP	ACC	REP	ACC	REP
Hip	4.6	1.4	4.5	0.9	0.8	0.3
Knee	5.7	1.0	7.8	2.8	4.7	1.1
Ankle	9.8	2.1	15.6	4.9	16.6	4.1

RESULTS

Table.1 shows maximum values of the repeatability and accuracy errors obtained averaging joint angles over the collected strides. The maximum value of repeatability error was of 4.9°, obtained for the ankle Abd/Add. The accuracy error has a maximum value of 16.6° for the ankle Int/Ext Rot. repeatability and accuracy errors were higher for ankle joint.

DISCUSSION & CONCLUSIONS

The obtained results encourage the use of the here presented procedure as an efficient way to perform the sensor-to-segment calibration and to assess the rotation among the GRFs. The low levels of accuracy and repeatability errors suggest that the calibration procedure can be considered scarcely affected by the variability of the subject in performing it. Highest error values were observed for the ankle joint, probably because of the assumption of the foot as a rigid body.

REFERENCES

[1] de Vries et al. (2009) *Gait & Posture* 29: 535-541 [2] Picerno et al. (2011) *Gait & Posture* 33: 373-378 [3] Cappa et al. (2009) *Gait & Posture* 30 (S2): S26-S27

HIGH VERSUS NORMAL BODY-MASS INDEX: EFFECTS ON 3D KINEMATICS AND KINETICS DURING DAILY-LIFE MOTOR TASKS

B. Callewaert[1], L. Labey[2], A. Leardini[3], J. Bellemans[4], K. Desloovere[5] and L. Scheys[2]

[1]C-MAL University Hospital, KU Leuven, Pellenberg, Belgium
[2]Smith & Nephew, European Centre for Knee Research, Leuven, Belgium
[3]Istituto Ortopedico Rizzoli, Movement Analysis Laboratory, Bologna, Italy
[4]KU Leuven, Department of Orthopedics and Traumatology, Leuven, Belgium
[5]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium

INTRODUCTION

Previous studies have investigated the impact of obesitas on level walking [1]. Little is reported in the literature about the effect of high body mass index (BMI) on full 3D kinematics and kinetics, especially during motor tasks other than gait. Therefore, the present study describes three-dimensional kinematics and kinetics of the lower limb in healthy subjects, respectively with normal and high BMI, during 11 functional daily-life motor tasks, with focus on the knee. A potential gender-related effect was analyzed. Furthermore, the effect of overweight on the knee joint was investigated.

PATIENTS/MATERIALS and METHODS

14 none-obese subjects (6 men, 8 women, 56±12 years, BMI 21.7±1.8) and 14 obese subjects (8 men, 6 women, 62±10 years, BMI 30±2.2) were included. Kinematic and kinetic data were obtained based on the Plug-in-Gait model (Vicon,Oxford) and 2 AMTI forceplates. A knee alignment device was used to identify the knee flexion/extension axis. One single investigator applied all markers on all participants to prevent inter-investigator variability in marker placement confounding potential BMI-related effects. 11 functional motor tasks with 3 repetitions each were performed by all subjects, including both gait tasks (walking, walk and crossover turn and sidestep turn, ascent onto a step, descent off a step, descent with crossover turn and sidestep turn) and non-gait tasks (sit-to-stand, mild and maximal squat and lunge).

RESULTS

Overall, the results indicated similar joint angle inter-subject variability for the obese and non-obese subjects. The analysis revealed statistically significant inter-subject variability of the hip flexion angle throughout the gait cycle between men (mean SD 4.05°) and women (mean SD 8.22°) both with high BMI. We also found a systematic offset towards decreased internal knee rotation during non-gait tasks in subjects with high BMI. Furthermore, an offset towards increased knee abduction was found, especially during gait tasks in subjects with high BMI, and most obvious in female subjects. Finally, a statically significant difference in the first peak of the knee adduction moment was found, which disappeared after mass normalisation. For walking the peak adduction moment for the normal BMI group was 442.9 Nm compared to 607.6 Nm for the high BMI group.

DISCUSSION & CONCLUSIONS

Surprisingly, the overall results highlighted that inter-subjects variability in typical subjects was not influenced by BMI, suggesting that high BMI is not a contra-indication for objective 3D knee motion analysis. However, gender specific analysis demonstrated that inter-subject variability increased in obese females, due to the difference in constitution and fat distribution in women compared to obese men. Thus, the BMI threshold for inclusion for 3D evaluation should be gender related. The transverse plane offset found for the knee in the non-gait tasks may be related to the increased knee valgus angle (crosstalk) in obese subjects. This knee valgus malalignment in these obese subjects induced shorter coronal lever arms, thereby preventing severe external knee adduction moments, when normalized to mass. However, the high body mass still resulted in severely increased knee loads (expressed by non-normalised knee moments) and may therefore have an important impact on the development of knee osteoarthritis [2].

REFERENCES

[1] Lai et. al, Clin Biomech, 23: 2-6, 2008

[2] Reijman et. al, Ann Rheum Dis, 66:158-162, 2007

INFLUENCE OF PELVIS KINEMATICS ON FOOT PROGRESSION ANGLE ALIGNMENT DURING GAIT

Ana Presedo[1], Anne L Simon[1], Fabrice Megrot[2] and Georges F Penneçot[1]

[1]Robert Debré Hospital, Orthopaedic Surgery, Paris, France
[2]CRF Bois Larris, Croix Rouge, Gait Laboratory, Lamorlaye, France

INTRODUCTION

Lack of normalization of foot progression angle after correction of lower limb torsional troubles raised the question about the influence of pelvis transverse plan kinematics on lower limb alignment during gait.

The goal of this study was to explore the influence of pelvis kinematics on foot progression angle deviations.

PATIENTS/MATERIALS and METHODS

We retrospectively reviewed kinematic data of 188 children with spastic diplegia who had not previous surgery. Data recorded at mid stance were: pelvic rotation, hip rotation, ankle rotation and foot progression angle.

RESULTS

Abnormal pelvis kinematics was noticed in 255 of 376 lower limbs (68%). Among 231 patients with internal foot progression angle, internal pelvic rotation was associated to other transverse plan kinematic deviations in 98 cases (42 %). For 78 patients who showed external foot progression angle, external pelvic rotation represented a combined cause in 22 cases (28%).

DISCUSSION & CONCLUSIONS

Pelvic transverse plan kinematics is difficult to analyse by means of observational gait analysis. This parameter can represent an isolated cause of abnormal foot progression angle but it is often combined with other transverse plan deviations. A detailed kinematic analysis of interaction between planes is an essential step when making surgical planning, particularly when foot progression angle is to be addressed.

REFERENCES

1. Gaston MS, Rutz E, Dreher T, Brunner R. Transverse plane rotation of the foot and transverse hip and pelvic kinematics in diplegic cerebral palsy. Gait Posture. 2011 juin;34(2):218–21.
2. Dreher T, Wolf S, Braatz F, Patikas D, Döderlein L. Internal rotation gait in spastic diplegia—Critical considerations for the femoral derotation osteotomy. Gait & Posture. 2007 juin;26(1):25–31.
3. De Morais Filho MC, Kawamura CM, Andrade PH, Dos Santos MB, Pickel MR, Neto RB. Factors associated with pelvic asymmetry in transverse plane during gait in patients with cerebral palsy. J Pediatr Orthop B. 2009 nov;18(6):320–4.
4. DeLuca PA, Davis RB 3rd, Ounpuu S, Rose S, Sirkin R. Alterations in surgical decision making in patients with cerebral palsy based on three-dimensional gait analysis. J Pediatr Orthop. 1997 oct;17(5):608–14.
5. Kay RM, Rethlefsen S, Reed M, Do KP, Skaggs DL, Wren TAL. Changes in pelvic rotation after soft tissue and bony surgery in ambulatory children with cerebral palsy. J Pediatr Orthop. 2004 juin;24(3):278–82.
6. Ounpuu S, DeLuca P, Davis R, Romness M. Long-term effects of femoral derotation osteotomies: an evaluation using three-dimensional gait analysis. J Pediatr Orthop. 2002 avr;22(2):139–45.
7. O'Sullivan R, Walsh M, Hewart P, Jenkinson A, Ross L-A, O'Brien T. Factors associated with internal hip rotation gait in patients with cerebral palsy. J Pediatr Orthop. 2006 août;26(4):537–41.
8. O'Sullivan R, Walsh M, Jenkinson A, O'Brien T. Factors associated with pelvic retraction during gait in cerebral palsy. Gait Posture. 2007 mars;25(3):425–31.
9. Kim H, Aiona M, Sussman M. Recurrence after femoral derotational osteotomy in cerebral palsy. J Pediatr Orthop. 2005 déc;25(6):739–43.
10. Wren TAL, Otsuka NY, Bowen RE, Scaduto AA, Chan LS, Sheng M, et al. Influence of gait analysis on decision-making for lower extremity orthopaedic surgery: Baseline data from a randomized controlled trial. Gait & Posture. 2011 juill;34(3):364–9.

ON DEVELOPING A WEARABLE SYSTEM FOR EVALUATING GAIT SYMMETRY

Yi-Hua Chen[1], Po-Chieh Lin[1] and Bing-Shiang Yang[1]

[1]National Chiao Tung University, Department of Mechanical Engineering, Hsinchu, Taiwan

INTRODUCTION

Gait characteristics are usually evaluated in clinical environments to assist diagnostic and intervention processes [1]. Many studies have used non-continuous parameters to assess gait symmetry, such as, stance time, swing time, stride time or ground reaction forces [1-4]. To further obtain continuous parameters during walking, the purpose of this study was to develop a wearable system and algorithms for evaluating gait symmetry.

PATIENTS/MATERIALS and METHODS

We developed a wearable system, consisting of four wireless sensor packages, each with a tri-axial accelerometer and a uni-axial gyroscope, and a data log. The four sensor packages were attached to the middle of the subject's left thigh, left shank, right thigh and right shank respectively. Normal walking (>10 m) data of three healthy subjects and two stroke patients were gathered for evaluating gait symmetry. Root mean square values of accelerations during walking were first calculated and a normalized cross-correlations [5] (Ccnorm), value 0~1, between the values from the left and right sensors were then computed respectively to determine the symmetry level for thigh and shank respectively. The closer the Ccnorm value to 1, the similar the gait pattern between left and right sides.

RESULTS

The normalized cross-correlation values (Ccnorm), i.e. an indicator of gait symmetry, were quantified for the three healthy and two stroke subjects. As hypothesized and observed during the experiment, the healthy subjects performed with more symmetric gait patterns than the stroke subjects. Although the Ccnorm values of thigh did not significantly differ between the normal and the stroke subjects, the Ccnorm values from shank (lower leg) sensors of the stroke subjects were significantly smaller, i.e. more asymmetric, than those of the normal subjects ($p<0.01$).

DISCUSSION & CONCLUSIONS

By using normalized cross-correlations of shank accelerations, we could quantify gait symmetry and distinguish normal walking from asymmetric walking (of stroke patients). The developed wearable system could be further used for clinical assessments. We are testing more subjects and establishing additional algorithms for evaluating gait characteristics.

REFERENCES

[1] M. Dewar and G. Judge, "Temporal asymmetry as a gait quality indicator," *Medical and Biological Engineering and Computing,* vol. 18, pp. 689-693, 1980.

[2] C. M. Kim and J. J. Eng, "Symmetry in vertical ground reaction force is accompanied by symmetry in temporal but not distance variables of gait in persons with stroke," *Gait & posture,* vol. 18, pp. 23-28, 2003.

[3] C. K. Balasubramanian, M. G. Bowden, R. R. Neptune, and S. A. Kautz, "Relationship between step length asymmetry and walking performance in subjects with chronic hemiparesis," *Archives of Physical Medicine and Rehabilitation,* vol. 88, pp. 43-49, Jan 2007.

[4] A. Crowe, M. M. Samson, M. J. Hoitsma, and A. A. van Ginkel, "The influence of walking speed on parameters of gait symmetry determined from ground reaction forces," *Human Movement Science,* vol. 15, pp. 347-367, 1996.

[5] D. Gouwanda and S. Arosha Senanayake, "Identifying gait asymmetry using gyroscopes--a cross-correlation and normalized symmetry index approach," *Journal of Biomechanics,* vol. 44, pp. 972-978, 2011.

RELIABILITY OF A SYSTEM USING ORIENTATION SENSORS TO MEASURE STANDING POSTURE - A PILOT STUDY

Tobias Stenlund[1], Fredrik Öhberg[2], Ronnie Lundström[3], Ola Lindroos[4], Alex Nassiri[1], Frans Unnermyr[1] and Börje Rehn[1]

[1]Umeå University, Dept. of Community Medicine and Rehabilitation, Physiotherapy, Umeå, Sweden
[2]Umeå University, Dept. of Radiation Sciences, Biomedical Engineering , Umeå, Sweden
[3]Umeå university, Dept. of Public Health and Clinical Medicine, Occupational Medicine, Umeå, Sweden
[4]Swedish University of Agricultural Sciences, Dept. of Forest Resource Management, Umeå, Sweden

INTRODUCTION

Posture or alignment is important to analyze in the field of ergonomics as an awkward posture might lead to back pain. Reliable and user-friendly methods for direct posture measurement are rare. A portable system for measurement and analysis of body posture and movement using orientation sensors has been developed by the department of Biomedical engineering and informatics at the Umeå University Hospital in Sweden. The system consists of 5 movement sensors, a wearable collecting device and software. Each sensor consists of 3 directional accelerometers and gyroscopes. The technique has previously been used in other settings measuring single joints.

Aim: The aim of this study was to test the inter- and subject variation of the system using orientation sensors on head and back for measuring posture.

PATIENTS/MATERIALS and METHODS

Repeated measures were done by four different test leaders. One healthy male participant with no ongoing problems from neck or back was included. The test leaders were one physiotherapist, two physiotherapy students and one biomedical engineer. Angular displacement were recorded from orientation sensors that was applied at the forehead, Th2, Th12, L3 and S2 and attached to the body with elastic Velcro straps and a customized vest. The participant repeated a standardized forward bending in standing, fingertip to knee-height, five times for each of the test leaders which were blinded from each other's measures.

RESULTS

Preliminarily data shows that the angular displacement for each segment combined for all measures in sagital plane in degrees (Mean, Range) was; Head (59, 53-65), Th2 (52, 45-58), Th12(53, 50-56), L3 (41, 36-45), S2 (24, 16-29). The angular displacement for segment S2 for the first repetition was; (23, 16-26) and fifth repetition was; (26, 23-29). The angular displacement for the same segment for each test leader, Leader (L) 1 (27, 26-29), L2 (19, 16-23), L3 (26, 25-26), L4 (23, 22-24).

DISCUSSION & CONCLUSIONS

Preliminary data indicates that there might be a variation between test leaders with an inter-examiner reliability of 14 degrees. The intra-subject variation was clearly better (2-7 degrees). The result indicates the necessity of standardizing measurements. Further analysis including more subjects will be performed.

REFERENCES

UNDERWATER GAIT ANALYSIS: A MARKERLESS APPROACH

Alberto Rigato[1], Zimi Sawacha[1], Silvia Fantozzi[2, 3], Francesco Pretto[1], Alice Mantoan[1], Matteo Cortesi[3], Silvia Del Din[1], Giorgio Gatta[3], Claudio Cobelli[1]

[1]University of Padova, Department of Information Engineering, Padova, Italy
[2]University of Bologna, DEIS, Bologna, Italy
[3]University of Bologna, Faculty of Exercise and Sport Sciences, Bologna, Italy

INTRODUCTION

The measurement of common biomechanical parameters during water locomotion is more demanding than in laboratory conditions, since most instruments are not suitable for operating in a water environment. Therefore, the development of new technologies is highly sought. In the present work, an automatic markerless motion capture system (MMC) [1] has been investigated and its accuracy in underwater (UW) three-dimensional (3D) lower limbs (LL) joint kinematics during walking reconstruction has been tested.

PATIENTS/MATERIALS and METHODS

Three healthy male subjects were recruited (mean age and BMI: 33.3±15.7 and 24.1±3.2). A video-based, MMC for the UW motion analysis was adopted as in Ceseracciu et al. [1]. Six walking trials at a self-selected speed have been acquired with 6 subaqueous video cameras (TS-6021PSC, Tracer Technology Co. Ltd) in a swimming pool with water at 1.20 m. Lower limb 3D joints kinematics was determined for each subject's walking trial. The Pearson's correlation coefficient was calculated for each subject's kinematic parameter, in order to select which of each subject's representative walking trials were to be included in the computation of the mean. Walking trials with a correlation coefficient lower than 0.75 were excluded from the statistical analysis [2]. For each subject, each joint rotations mean±1 SD were estimated. Inter-subjects mean and SD were calculated and thus UW Markerless Bands were obtained and then compared with the state of the art, represented by Normative Out of Water (OW) Bands [2]. Accuracy and reliability of the proposed technique were evaluated by means of comparison with 3D joint kinematics estimated with traditional manual digitization (MAN) using a dedicated software (SIMI Reality Motion Systems GmbH). In order to compare the 2 techniques, knee joint planar angles were evaluated on each subjects and root mean square distance (RMSD) values between angles estimated.

RESULTS

Mean, SD and range of motion (ROM) of hip, knee and ankle joints' angles were reported in Table 1. RMSD mean value between knee 2D angles evaluated with MAN and markerless techniques was found equal to 8.1°.

	Hip			Knee			Ankle		
	mean	SD	ROM	mean	SD	ROM	mean	SD	ROM
flex-ext [deg]	-14.1	13.5	61.8	14.8	13.8	50.1	-1.4	6.0	37.0
abd-add [deg]	3.4	3.0	20.0	-	-	-	/	/	/
inv-ev [deg]	/	/	/	/	/	/	-1.7	3.0	7.6
in-exrotation [deg]	1.4	0.4	15.6	-	-	-	-0.6	3.2	11.1

Table 1: Mean, SD and ROM of hip, knee and ankle joint angles.

DISCUSSION & CONCLUSIONS

Results show the feasibility of the present approach. A limitation of the study is that, even though MMC has been conceived aiming at 3D analysis [1], in this context planar angles evaluation is required for the comparison with state of the art [3]. Differences between the 2 methodologies are due to the fact that SIMI planar angles estimation relies on anatomical landmarks identification on each video sequence by manual digitization, meanwhile the MMC approach is based on automatic reconstruction of joint centre positions. Future developments will be the extension of this study to a larger sample of subjects and the comparison between 3D joint angles estimated with the 2 different techniques.

REFERENCES

[1] Ceseracciu et al. (2011) Markerless analysis of front crawl swimming. *J. of Biomechanic*s.

[2] Sawacha et al. (2009) *Clinical Biomechanics*, 24(9):722-728.

[3] Barela et al. (2008) *J Electromyogr Kinesiol*. 18(3):446-54.

VALIDATION OF A MOTION CAPTURE LABORATORY AND A NEW MARKER-PLACEMENT PROTOCOL FOR CLINICAL APPLICATIONS

Tim Weber[1], Silvia Dullien[1], Joachim Grifka[1], Tobias Renkawitz[1] and Sebastian Dendorfer[2]

[1]University Medical Center, Department of Orthopedics, Regensburg, Germany
[2]University of Applied Science , Laboratory for Biomechanics, Regensburg, Germany

INTRODUCTION

Clinical gait analysis has been proven to be a valid technique in order to reveal pathologies that concern ones gait. The greatest potential lies in capturing even the smallest abnormalities in ones gait. Body fixed sensors for gait analysis have been introduced several years ago. Following specific marker protocols the (often) motion-capture (MoCap) markers are applied on anatomical (bony) landmarks on the subject's body, which serve to calculate joint kinematics. These results are of course dependent on the examiners themselves and on the used marker placement protocol. This study introduces a method to measure the accuracy and sensitivity of a motion capture gait laboratory, a new marker placement protocol and the examiners conducting the gait analysis in order make evident statements.

PATIENTS/MATERIALS and METHODS

This study is divided into three different experiments. First, the gait laboratory itself is compared to a state of art rigid body measuring device without human interaction. Ten markers are placed on a standard cross table in the measuring volume of the gait laboratory. By means of the cross table different spatial positions of the markers are achieved while the measuring devices are capturing the positions simultaneously. The positions are then compared amongst each other. Secondly, the tracking sensitivity of the markers is determined by means of one experiment on a healthy subject. This is being tracked ten times by three different examiners and the positions of the MoCap – Markers are compared for every time step, respectively. The third experiment was conducted in order to determine the difference and the significance of applying of the MoCap - markers on the bony landmarks of the subject. The marker protocol was applied ten times on the bony landmarks of the subject by two different examiners in an alternating manner. After each application a gait experiment was conducted, which resulted in comparing marker trajectories and joint kinematics.

RESULTS

Differences between rigid body measuring device, the MoCap laboratory and the cross table were not severe enough to limit the gait analysis capabilities of the system. The differences between inexperienced and experienced examiners were present. The application of the marker placement protocol showed differences between the examiners, however once the marker trajectories are translated into joint kinematics the differences were non-significant.

DISCUSSION & CONCLUSIONS

This study introduces a method to measure the accuracy and sensitivity of a fully equipped motion capture gait laboratory, a new marker placement protocol and the examiners conducting the gait analysis. The results indicate differences between examiners. However they mostly disappeared after a learning curve of the persons. Also they had only little influence on the kinematics derived from the marker trajectories. This article analyses a new marker protocol and gait lab set up on several levels and thus validates the accuracy and sensitivity of the system which is crucial in order to be able to make valid statements about gait kinematics.

REFERENCES

ETHNIC SPECIFIC 3D KNEE MOTION DURING DAILY-LIFE ACTIVITIES: CAN JAPANESE AND CAUCASIAN REFERENCE DATABASE BE MERGED?

B. Callewaert[1], L. Scheys[2], J. Bellemans[3], S. Fukagawa[4] and K. Desloovere[5]

[1]C-MAL, University Hospital, KU Leuven, Pellenberg, Belgium
[2]Smith & Nephew, European Centre for Knee Research, Leuven, Belgium
[3]KU Leuven, Deparment of Orthopedics and Traumatology, Leuven, Belgium
[4]KKR Chihaya Hospital, Higashi-ku, Fukuoka-shi, Japan
[5]KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium

INTRODUCTION

Previous studies have suggested variations in knee joint biomechanics between Caucasian and Japanese populations [1]. However very few studies have reported 3D kinematics and kinetics during more complex daily-life motor tasks. Therefore, the objective of the study was to analyze 3D joint motion during functional motor tasks in healthy Caucasian and Japanese subjects, with special focus on the knee joint.

PATIENTS/MATERIALS and METHODS

Upon ethical approval, 40 healthy adults participated in this study after giving informed consent. 20 Caucasian subjects (9 men, 11 women, 32.4±9.3years, BMI 22.5±3.5) and 20 Japanese subjects (10 men, 10 women, 30.1±6.6years, BMI 20.7±2) were included. Kinematic data were obtained using a 14 camera motion capture system tracking the 3D positions of 23 retro-reflective markers (Plug-in-Gait,Vicon,Oxford). Eleven functional motor tasks, 3 repetitions each were performed by all subjects, including gait tasks (walking, walk and crossover turn and sidestep turn, ascent onto a step, descent off a step, descent with crossover turn and sidestep turn) and non-gait tasks (sit-to-stand, mild and maximum squat and lunge. In addition, each subject was asked to maximally rotate the trunk around the vertical axis, while keeping the knees extended and the feet fixed to the ground, inducing maximal axial rotations in the knee (thereby reflecting the level of joint laxity).

RESULTS

Japanese subjects showed a significant increased peak knee flexion angle (21.2%) for maximum SQUAT. We thereby also observed a significant higher excursion of the coronal and transverse knee kinematics with a significant increased peak internal rotation angle of the knee (54.0%). The mean knee adduction moment during squat was higher in the Japanese group (160.6Nm) compared to the Caucasians (121.34Nm). Furthermore, trunk rotation was characterized by higher excursions for out-of-sagittal plane rotations (Table 1). For all GAIT tasks, a significant decreased knee extension angle at terminal stance was found for the Japanese subjects (2.4º) compared to the Caucasians (6.4º). The tendency to a more flexed knee gait pattern resulted in a premature internal knee extension moment at terminal stance. Gait speed was higher compared to the Caucasian subjects.

DISCUSSION & CONCLUSIONS

This study demonstrates the need for an ethnic specific reference database for 3D knee motion during daily-life activities. Squatting is a common daily posture in Asian populations. The increased range in out-of-sagittal rotations seen during trunk rotation confirms the suspected joint laxity, resulting in higher excursions during maximum squatting. The increased mean knee adduction moments induces higher loads on the knee joint. Several studies have demonstrated the association of prolonged squatting and the incidence of tibiofemoral knee osteoarthritis [2]. Furthermore, despite the increased walking speed, Japanese subjects showed decreased knee extension in stance, compared to Caucasian populations, resulting in a premature knee extension moment at terminal stance, and thus suggesting a slightly reduced energy conservation.

REFERENCES

[1]Leszko et. al, Clin Orthop Relat Res, 469(1): 95-106 [2]Zhang et. al, Arthrits & Rheumatism, 50(4): 1187-1192

EMG ACTIVITY DURING ROBOTIC ASSISTED GAIT TRAINING: A CASE STUDY

Marianna Romei[1], Claudio Corbetta[2], Luigi Piccinini[2], Elena Beretta[3] and Anna C Turconi[2]

[1]IRCCS E.Medea, Bioengineering Department, Bosisio Parini (LC), Italy
[2]IRCCS E.Medea, Functional Rehabilitation Dept., Bosisio Parini (LC), Italy
[3]IRCCS E.Medea, Neurorehabilitation Dept., Bosisio Parini (LC), Italy

INTRODUCTION

Robotic assisted gait training (RAGT) is a rehabilitation strategy that promotes the recovery of walking following neurological gait disorders, both in adult and in pediatric population [1,2]. Many training parameters can be set, among which the percentage of body weight support, and the patient can perform passive or active movement. The lower limb muscle activity during RAGT was investigated in adult subjects [3].
The aim of this case-study was to compare EMG activity of lower limb muscles in a 10-years old girl during RAGT according to different body weight supports and patient's passive/active movement.

PATIENTS/MATERIALS and METHODS

DL is a ten years old girl affected with left hemiplegia due to vascular cerebral lesion, who had RAGT on pediatric Lokomat (Hocoma, Zurich,CH).
During RAGT, bilateral surface EMG activity of soleus (SOL), vastus medialis (VAM) and biceps femoris caput longus (BFCL) was recorded using FreeEMG (Bts, IT) at 1000Hz for at least 20 sec. Three training conditions were tested: A) 100% of body weight (BW) supported by the Lokomat and passive movement; B) 100% of BW supported by Lokoma t and active movement, C) 20% of BW supported by Lokomat and active movement.

RESULTS

During A condition there was EMG activity only on healthy limb muscles. When the patient was asked to perform active movement, EMG activity was present in sound and impaired limbs, both during fully BW support and with 20% of BW support.

DISCUSSION & CONCLUSIONS

This case study showed that during RAGT EMG activity of impaired limb muscles was present only when the patient performed active movement and seemed increase when the BW Lokomat support was reduced. EMG activity of sound limb muscles was present during passive movement too (SOL and BFCL) and seemed increase during active movement passing from 100% BW to 20% BW of Lokomat support. These data suggest that during RAGT is important that the patient performs active movement in order to increase its muscles activity.

REFERENCES

[1] Mayr et Al., Neurorehabil Neural Repair. 2007; 21: 307-14
[2] Meyer-Heim et Al., Arch Dis Child 2009; 94:615-620
[3] Hidler JM, Wall AE. Clin Biomech 2005; 20: 184-193

P96

DIRECTION TRANSLATION PROTOCOL (DTP): A NEW SIMPLE TEST FOR OBJECTIVE EVALUATION OF THE MOVEMENT EFFICIENCY USING THE GAIT LABORATORY EQUIPMENT.

Nikolaos Darras[1], Magda Tziomaki[1], Dimitris Pasparakis[2], Christos Nestoridis[1] and Manoussos Pentarakis[1]

[1]ELEPAP, Gait & Motion Analysis Center, Athens, Greece
[2]"Aglaia Kyriakou" Children's Hospital, 2nd Orthopaedic Dept, Athens, Greece

INTRODUCTION

Gait analysis provides comprehensive documentation on the biomechanical issues of a patient during level walking. There are though other parameters of movement, like maintaining direction & turning, as well as the ability to maintain pace that are not addressed by gait analysis. Various simple tests exist for assessing individual parameters[1]. The aim of the project was to create a new easy to perform gait lab test, that uses the existing equipment to assess objectively these extra parameters. It was considered that this information can be very useful for various pathologies especially for comparisons before and after various treatments. The idea was to create a simple protocol that can be performed from subjects with different abilities even those that use commodities like crutches, rollators or even wheel chair.

PATIENTS/MATERIALS and METHODS

Gait lab 3D motion analysis system is used to record the trajectories of two markers that are placed on the subjects shoulders (acromion). A 2.5 m distance area is defined in the center of the gait lab walkway using cones. The subject is then asked to walk for 5 full rounds around the cones clockwise (Total Distance = 25m) and after an interval of 3 min another 5 full rounds anti-clockwise The instructions are: a) keep a steady and comfortable pace, b) stay close to the cones at all times and c) to perform 6 full rounds. The protocol is usually repeated 2 times per direction. Before starting 3 rounds clockwise and 3 anti-clockwise are allowed for practice. The collected 3D co-ordinates are then processed to create a virtual marker which is located in the middle of the distance of the 2 shoulder markers. The X,Y,Z trajectories of the virtual marker are then processed for calculating all the parameters for the analysis. The parameters analyzed are: Total XY trajectory length, Lap & Semi-Lap Trajectory Length, Total Time and Lap & Semi Lap Time. Max trajectory values in X axis (sagital)and Y axis (frontal). An algorithm that has been developed, divides the trajectories in straight (2.0 m) and turning divisions (0.5 m). Straight Time and Turning Time as % of the Lap Time are also calculated. Preliminary data from 1 Male & 1 Female adult normal subject are presented. The subjects were measured in two different moments of the day for two different days a week apart. Descriptive statistics and Coefficients of Variation (CV) are presented for the parameters measured for the Male (M) and the Female (F).

RESULTS

Mean Total XY trajectory length: M=28. 8 ± 1.25 m (CV = 4%) & F =29.15 ± 1.05 m. Mean Total Time: M = 31.12 ± 1.6 sec (CV = 5%) & F = 31.69 ± 1.21 sec (CV = 4%). Mean Lap Time: M = 6.10 ± 0.22 sec (CV = 4%) & F = 6.40 ± 0.25 sec (CV = 4%). Mean 2m Straight Division Time: M = 1.86 ± 0.05 sec (CV = 3%) & F = 1.89 ± 0.02 sec (CV = 1%). Mean 0.5 m Turning Division Time: M = 1.20 ± 0.01 sec (CV = 1%) & F = 1.31 ± 0.02 sec (CV = 2%). Straight Division (% Lap Time): M = 61.0 ± 0.02 % (CV = 4%) & F = 59.0 ± 0.01 % (CV = 3%). Turning Division (% Lap Time): M = 39.0 ± 0.03 % (CV = 7%) & F = 41.0 ± 0.02 % (CV = 4%).

DISCUSSION & CONCLUSIONS

Preliminary data of a new measurement tool for the evaluation of movement efficiency are presented. These results document objectively new aspects of movement efficiency, such as the ability to maintain trajectory, which has impact on the work that the subject exerts, the ability to manoeuvre during turning, the consistency of the pace of the subject etc. Although the repeatability and reliability of the test are still under assessment for normal subjects and patients, the CVs of the preliminary data presented, show satisfactory values of variation.

REFERENCES

[1] Wolf SL, Catlin PA, Gage K, Gurucharri K, Robertson R, Stephen K. Establishing the reliability and validity of measurements of walking time using the Emory Functional Ambulation Profile. Phys Ther. 1999;79(12).

THE COMPARISON OF THE EFFECT OF MEDIAL LONGITUDINAL ARCH SUPPORT, HEEL & SOLE WEDGES ON THE PELVIC ALIGNMENT DURING STANCE PHASE OF GAIT IN FLAT FOOTED SUBJECTS

Mohsen Razeghi[1], Ali Ghanbari[1], Samaneh Ebrahimi[1], Farzaneh Yazdani[1] and Elahe Shoara[1]

[1]Center of human motion sciences, School of Rehabilitation, Shiraz University of Medical Sciences, Shiraz, Iran

INTRODUCTION

Excessive foot pronation, which is a serious anatomical abnormality, has been associated with low back pain due to generating changes in the lumbopelvic alignment [1, 2]. Several researchers revealed the possibility of a relationship between subtalar hyperpronation and shank, thigh, pelvis and lumbar malalignment. Therefore, excessive pronation may lead to several anatomical and functional problems in the lower extremity joints and segments [3]. Various types of orthotic devices have been introduced in order to unload the medial longitudinal arch and reduce the flat foot complications on the other joints. The purpose of this study was, therefore, to compare the pelvic alignment while applying three different insole orthotics.

PATIENTS/MATERIALS and METHODS

10 female subjects (aged 19-25 years) with functional pes planus (rear foot angle ≥ 4) were investigated. Retroreflective markers were placed on the body of the subjects. The kinematic data were collected by a six camera motion capture system (Qualisys®, Ltd., Sweden) while the subjects walked at a preferred speed in four different test situations: simple insole (no correction), insole with medial arch support, insole with medial arch support and medial heel wedge, and insole with medial arch support and lateral fore foot wedge.

RESULTS

Applying a medial arch support with lateral wedge significantly reduced the pelvic angle in sagittal plane in comparison with simple insole($11.69°\pm1.67$, $13.12°\pm1.72$ respectively) ($P=0.005$). However, the two other insoles did not affect this angle ($P>0.05$).

DISCUSSION & CONCLUSIONS

Medial arch support with lateral forefoot wedge decreased the anterior pelvic tilt in flat footed subjects. This insole may reduce the functional foot malalignment by unloading the medial longitudinal arch and decreasing the hind foot pronation and forefoot supination. However, the other orthotics did not significantly decrease the sagittal pelvic angle probably because they could not alter the alignment of foot sufficiently. It can be concluded that a medial arch support with lateral forefoot wedge has an immediate effect on reducing the anterior pelvic tilt. Therefore, it may minimize the possibility of musculoskeletal injuries in flat footed subjects.

REFERENCES

[1] Khamis S, et al. (2007). Gait and posture. 25:127-134.

[2] Pinto R, et al. (2008). Manual Therapy. 13:513-519.

[3] Tiberio D, et al. (1988). Phys Therapy. 68:1840-1849.

THE EFFECT OF SUBTALAR HYPER PRONATION ON THE PELVIC ALIGNMENT DURING STANCE PHASE OF WALKING

Ali Ghanbari[1], Mohsen Razeghi[1], Farzaneh Yazdani[1], Samaneh Ebrahimi[1] and Leila Abbasi[1]

[1]Center of human motion sciences, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran

INTRODUCTION

Strong interactions exist between the segments of human body [1]. The pelvis, which is located in the center of the body, has an important responsibility for connecting the upper body musculoskeletal system to the lower body; Thus, it may both affect and be affected by postural alterations of upper and lower segments, increasing the risk of low back pain [2]. Previous studies have found that hyperpronation is highly prevalent [3]. The aim of this study was to examine the relationship between subtalar hyperpronation and pelvic alignment during the stance phase of walking.

PATIENTS/MATERIALS and METHODS

10 subjects with neutrally aligned feet and 10 with hyperpronated feet (rear foot angle ≥ 4) aged 23 ± 2.5 years were selected after a complete lower extremity clinical examination. Retroreflective markers were placed on the body of subjects. The kinematic data were collected by a six camera motion capture system (Qualisys®, Ltd., Sweden). Mean pelvic positions in the sagittal and frontal plane were calculated during the stance phase of walking.

RESULTS

A significant higher amount of mean pelvic sagittal angle was found in the flat footed group compared to normal group ($13.12° \pm 1.72$, $6.90° \pm 1.98$ respectively) ($P<0.0001$). Also the mean pelvic angle in frontal plane was statistically different in flat footed subjects in accordance to normal ones ($3.64° \pm 1.27$, $2.37° \pm 1.22$ respectively) ($P= 0.015$).

DISCUSSION & CONCLUSIONS

The pelvic alignments in both sagittal and frontal planes were different between the subjects with and without hyperpronation. This finding is in accordance with the study by Khamis and Yizhar [2]. The change in sagittal plane was towards anterior pelvic tilt. The subtalar pronation generates a lower limb internal rotation at the hip joint, locating the femoral head in a posterior position, which may lead to a posterior shift of the pelvis and trunk anterior deviation. So the anterior pelvic tilt occurs as a consequence. Also the calcaneal eversion causes a functional shortening of the lower limb and therefore induces a pelvic lateral tilt toward the weight bearing limb [2].

REFERENCES

[1] Razeghi M, et al. (2000). Sports Med. 29:425-438.

[2] Khamis S, et al. (2007). Gait and posture. 25:127-134.

[3] Pinto R, et al. (2008) Manual Therapy. 13:513-519.

Notes

Notes

INDEX OF AUTHORS

COMMERCIAL EXHIBITION

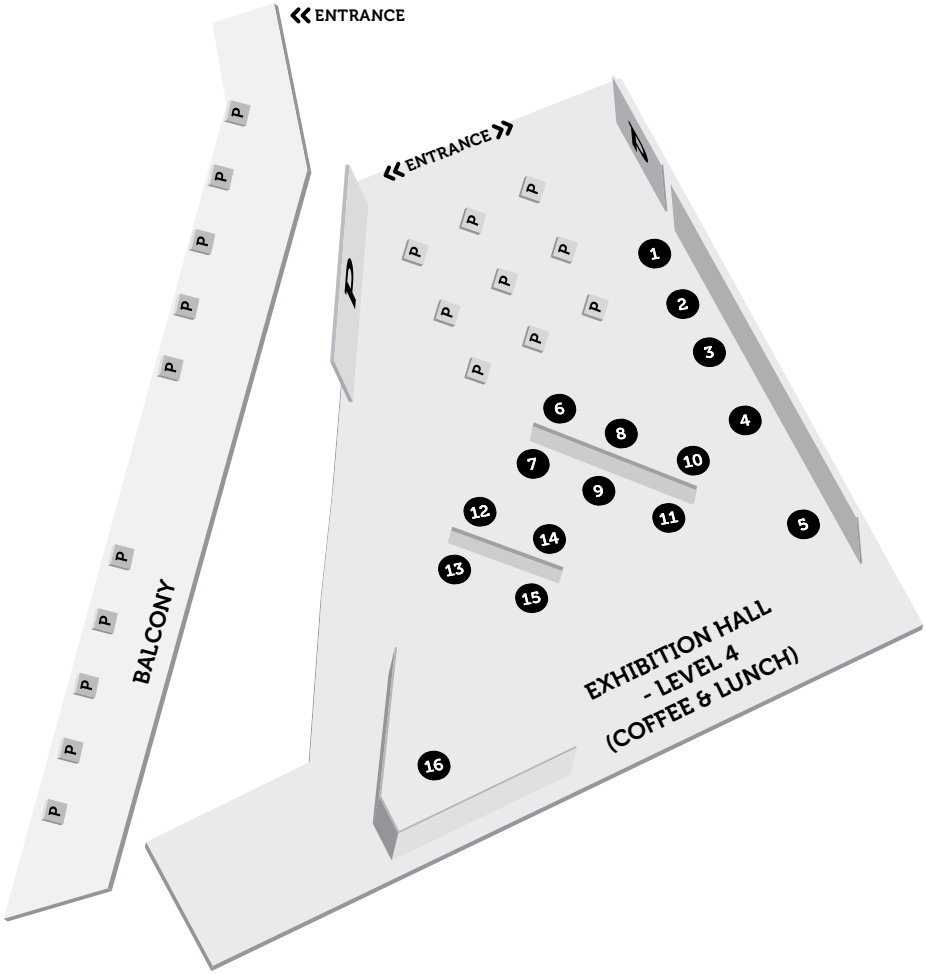
Exhibition open hours

Thursday, September 13th, 2012	08.00 – 19.00
Friday, September 14th, 2012	09.00 – 18.00

List of exhibitors

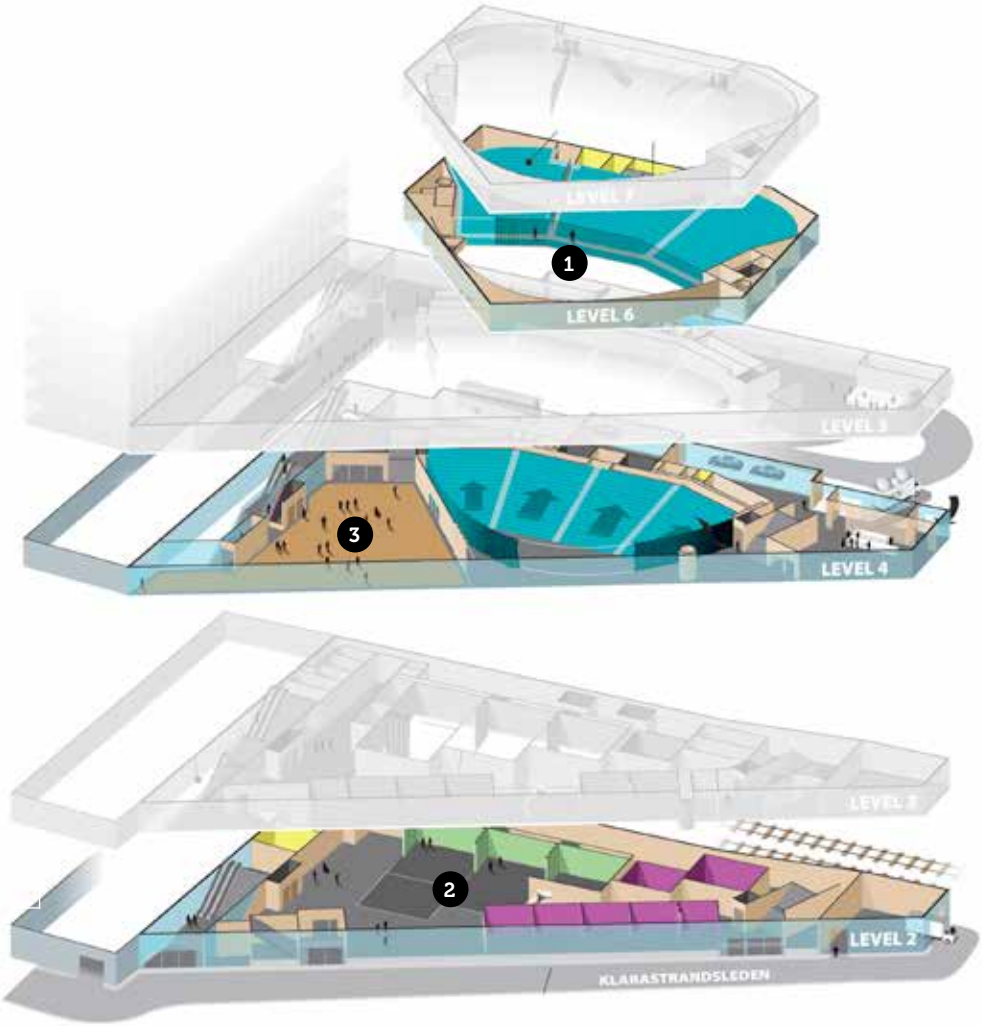
AMTI
AnyBody Technology
Bertec
Codamotion
Cometa
Contemplas
Fior & Gentz
Lion Systems
Microgate
Motek Medical
Noraxon
Novel
Prophysics
Qualisys
RSscan International
Simi Reality Motion Systems
TeamOlmed
Ultraflex Europe by Dirame Ortho
Velamed
Vicon

FLOORPLAN EXHIBITION HALL



P Posters
1 RSscan International
2 Simi Reality Motion Systems
3 Velamed | Bertec | Microgate | Noraxon
4 Novel
5 Vicon Motion Systems
6 TeamOlmed
7 Anybody Technology
8 Lion Systems
9 UltraflexEurope by Dirame Ortho
10 Motek Medical
11 Contemplas | Prophysics
12 Cometa Systems
13 Fior & Gentz
14 Codamotion
15 AMTI
16 Qualisys

FLOORPLAN STOCKHOLM WATERFRONT CONGRESS CENTRE



1. A2, Main Lecture Hall - LEVEL 6
2. C4, Lecture room - LEVEL 2
3. Exhibition hall - LEVEL 4 (Coffee & lunch)

AMTI

AMTI has collaborated with top researchers to develop a wide range of force plates and instrumented biomechanics equipment. We offer many standard six-degree-of-freedom products and also regularly partner with individuals to create custom solutions for highly specialized applications.

Our standard products include mounted force plates, portable force plates, instrumented treadmills, instrumented stairs, and instrumented walkers. We are also heavily involved in the field of biotribology, where our joint simulator machines are the industry standard for the evaluation of joint prosthetics.

AnyBody Technology

AnyBody Technology provides software and consulting services for musculoskeletal analysis of daily activities. A validated full-body model with an unprecedented level of detail efficiently computes in-vivo kinematics and dynamic individual muscle and joint forces and many other properties of the musculoskeletal system. The body model is scalable and open allowing users to perform an automated optimized model fit to the subject to achieve maximum accuracy.

Spun-off from university research in 2002, the company employs a multinational team of experienced experts servicing customers in hundreds of organizations in Asia-Pacific, Europe, and the Americas.

Bertec

”Bertec Corporation is a global leading manufacturer of the most accurate force measuring instruments on the market today. Bertec makes force plates, load cells, instrumented treadmills, custom transducers and balance plates used for research, rehabilitation and for sports applications”

CM Codamotion

“The Codamotion system was designed from the beginning for use in clinical movement analysis applications, and this remains a primary use of the system.
Codamotion sensor units are in operation in leading gait laboratories, hospitals, clinics and universities throughout the world.

Being portable, the Codamotion system can be used to provide mobile clinical services. A system can be up and running at a new location within minutes.
The Codamotion system allows clinicians to quantify and interpret human locomotion. Clinicians can acquire full 3D bilateral movement data in real-time. Centres have the ability to analyse and document thousands of patient trials across normal and pathological populations. The system can be combined with force platforms and EMG systems to give kinetic analysis and muscle activity information. Video can also be used with high speed cameras.”

Cometasystems

Designer and producer of the first wireless EMG systems, now with accelerometers, impedance check and up to 32 channels, Cometa is committed to provide the best technology for all budgets. Our systems are used and known worldwide for high signal fidelity and reliablity, thanks to our proprietary protocol of transmission. The longest battery life in the field, the smallest probes and the contactless recharge make them the most suitable systems to be integrated in your gait lab or to be used as a standalone EMG with our analysis software

Contemplas

CONTEMPLAS GmbH, with its headquarter in Kempten/Germany, develops and distributes worldwide software solutions for gait, posture and general motion analysis in the medical and sports market.

The CONTEMPLAS motion analysis software TEMPLO
offers the possibility to do analysis in different fields of applications, as Clinical Gait Analysis, 2D/3D Posture Analysis, Running Analysis, etc.

With the easy data acquisition and integration of other systems in the analysis process, such as EMG and pressure/force measuring systems, TEMPLO becomes an essential tool in the field of sport, medicine and science.

User- friendliness and dedicated analysis protocols based on the integration of the latest video technology help you while performing your analyses..

User- friendliness and dedicated analysis protocols based on the integration of the latest video technology help you while performing your analyses.

Dirame

UltraflexEurope is a division of Dirame Ortho and is Ultraflex Systems USA's European, Middle East and African master distributor and education & clinical support centre. We provide Education, Supply of components, Central fabrication, Full service (we do everything from evaluation, casting, manufacturing, to final fitting.) Dirame is also exclusive importer and distributor for other international manufacurers. Ultraflex-Europe by Dirame, Assesteenweg 21-29, BE – 1740 Ternat (Brussels) – Belgium

Fior & Gentz

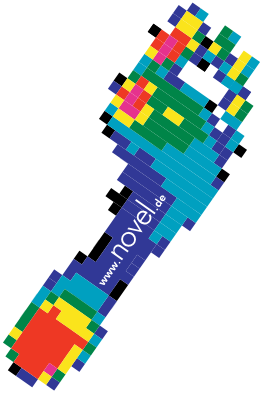
FIOR & GENTZ, a limited liability company, was founded in Lueneburg, Germany (close to Hamburg) on March 1st, 1997 and dedicates itself to the development and sales of orthotic products. This includes therapeutic shoes for different indications as well as system components for the production of orthoses for paralysed patients. We would like to provide Orthotists/Prosthetists worldwide with techniques and products so that they can treat patients in an optimum way and at the highest level. Affected people can gain new mobility due to the latest technology. Further information you will find at www.fior-gentz.com.

Microgate

North-Italian company founded in 1989, deals daily with high technology challenges: management systems for telescopes, professional timing devices and, last but not least, sport-performance/movement analysis systems. The company provides various solutions for biomechanical evaluation through optical sensors together with video cameras and photocells systems.
www.microgate.it info@microgate.it

Motek Medical BV

GRAIL is our latest innovative product: a complete solution not only for gait analysis, but also for gait re-training. All the parameters you traditionally find in gait reports, i.e. spatio-temporal parameters, kinematics, kinetics, are available in real-time. Deviations in gait can be identified on the fly or using an off-line gait analysis tool. Subsequently the deviating parameters can be modified using the functionality of the D-Flow software in a Virtual Environment with custom made applications. Real time gait adaptations can be accomplished by affecting a gait parameter using real-time feedback at a specifically selected period during the gait cycle.



Novel

The company novel (Munich, Germany) brought pedography to medical science as a functional method of diagnosis of the foot.
Founded in 1978, novel is distributing a complete system of foot analysis with the aid of pedography. This method has been scientifically tested worldwide. In only 8 minutes time, the physician or therapist is issued an analysis of the biomechanical function of both feet as an HTML file readable with any common browser. The procedure starts with the data collection from the novel database. For detailed information on all products offered by novel please visit www.novel.de.

myon prophysics

Prophysics

Prophysics, established in 1996, is a Switzerland-based company offering high-quality measurement equipment for the 2D and 3D analysis of motion as well as EMG and other biophysical signals. Working with industry leading companies such as Vicon, AMTI, Contemplas and Zebris, prophysics has established a strong user base and a reputation for excellent end-user support in German-speaking Europe. myon, also based in Switzerland, was established in 2008 to design and manufacture wireless measurement devices for EMG and other biophysical signals. In close cooperation with prophysics, a world-wide user base for the state-of-the-art myon 320 wireless EMG system has been established, offering customers ease of use, low latency and excellent synchronization. Together, myon and prophysics are pleased to offer clinical, sports, ergonomics and other users world-wide hardware and software solutions for EMG measurement and analysis. Additionally, prophysics continues to supply hardware and software for motion analysis as well as excellent pre- and post-sales support.

Qualisys

Qualisys is a leading, global provider of products and services based on mocap. The core technology of Qualisys products has been developed in Sweden since 1989. The experienced Qualisys staff has created a unique platform for optical motion capture, and Gait specialists all over the world rely on Qualisys' leading motion capture technology. The Project Automation Framework, PAF for QTM is a customizable infrastructure that lets you automate repetitive tasks in your workflow. Analyze a series of captures and create reports with the click of a button. Being fully customizable, PAF is the ultimate workflow tool for gait users.

Simi Reality Motion Systems

Simi Reality Motion Systems GmbH offers a wide range of software and hardware for applications in the fields of sports science, physical education, medicine, industry, entertainment and behaviorism. It includes software and turnkey solutions for motion capture, automatic tracking, coaching, athlete feedback as well as motion analysis for scientific and educational purposes.

teamolmed

TeamOlmed

TeamOlmed produce and provides patients with orthopedic devices. Products provided include prosthetics, orthotics, corsets, shoes and insoles. Our company has 300 employees where our largest customers consist of several counties throughout Sweden. At our center for children in Solna our CPO's and technicians have great experience in prescribing, developing and manufacturing orthopedic devices for children. For clinical analysis and evaluation of our products' effect on our patients' gait, we use a 2-dimensional motion analysis system. With close cooperation of parents, medical doctors, physical therapists and occupational therapist we commit to always fulfill the child's needs seen from a complete perspective.

velamed
SCIENCE IN MOTION

Velamed

Velamed is a German company specialized in professional planning and implementation of biomechanical labs. Velamed cooperates with the leading international manufacturers in the area of biomechanics and sensor systems to meet the highest expectations of its European academic and clinical customers. Velamed also works closely with its suppliers regarding the advancement and connectivity of the different systems.
www.velamed.com
info@velamed.com

Vicon

Vicon delivers highly accurate 3D motion capture systems for use in gait analysis. Nearly 400 clinical gait labs world-wide use Vicon technology. Its flagship camera line, the Vicon T-Series, offers the highest resolution, frame rates and accuracy available, allowing detailed motion capture in almost any environment. Bonita is Vicon's next generation camera, combining size, power, and price performance into one amazing solution.
Vicon's global clients include: University of Vienna; Nuffield Orthopaedic Centre; University of Brussels; Karolinska Institute; Guy's and St Thomas' Hospital; Katholieke Universiteit Leuven; Amsterdam Medical Centre; and Humboldt Universitat zu Berlin. For more information please visit www.vicon.com.

Lion Systems

Lion Systems a Luxembourgish company specialized in developing and customizing high performance optical measuring systems based on innovative technologies. The research areas include clinical applications (dynamic foot scanner, foot motion analysis, gait analysis systems) and industrial quality supervisions (solar panel, steel beam, artwork, engine inspection). Lion Systems also participates in several research projects in order to optimize their products and to develop new technologies. Main collaborators and customers are Adidas, ArcelorMittal, Delphi, Goodyear, Rehazenter, DFKI, Brussels University.

Noraxon USA, Inc.

Noraxon USA provides market leading technology in measurement and training devices, such as EMG, gait analysis, biofeedback and 2D/3D motion analysis that enables a unique approach to a fully equipped analysis and therapy concept for clinical and research applications.
The leader in Human Performance Measurement Solutions for over 25 years!
www.noraxon.com

RSscan International

RSscan International offers professional solutions for highly accurate dynamic pressure measurements. This is done by use of our renowned footscan® systems.
Our primary aim is to offer the costumer an affordable pressure measurement system with the best specifications to obtain an accurate result, combined with the clearest and easiest user interface in hardware and software.
To reach these goals, our hard- and software developers use-state-of the-art technology resulting in a high quality pressure measurement system for clinical, scientific and industrial use. We cooperate with several international universities, to validate the hard- and software parameters of the footscan® system.

	Thursday Sept 13	Friday Sept 14	Saturday Sept 15
08.00-09.00	Registration		
09.00-09.10	Opening & Welcome A2	Session 4a & 4b Orthotics A2 Adult Orthopeadics C4	Session 7 Balance and Posture A2
09.10-10.00	Session 1 Children's Orthopeadics A2		
10.00-10.30	Coffee & Exhibition	Coffee & Exhibition	Coffee
10.30-11.15	Baumann lecture A2	Session 5a & 5b Upper extremity A2 Foot C4	Keynote Lecture III A2
11.15-12.00	Session 2a & 2b Imaging methods A2 Knee Osteoarthritis C4		Session 8 Cerebral Palsy Spasticity, Muscle and Gait A2
12.00-13.00	Lunch & Exhibition	Lunch & Exhibition	Awards Closing A2
13.00-14.30	Poster presentations Exhibition Hall & Balcony	Poster presentations Exhibition Hall & Balcony	
14.30-15.00	Keynote Lecture I A2	Keynote Lecture II A2	
15.00-15.30	Coffee & Exhibition	Coffee & Exhibition	
15.30-17.00	Session 3a & 3b Cerebral Palsy Descriptive A2 Technical and Simulation C4	Session 6a & 6b Cerebral Palsy Effect A2 Gait Assessment C4	
17.15-19.00	ESMAC Annual General Meeting		
19.00	User Group Meetings		
19.30		Gala dinner at Junibacken	

QUALISYS

Motion Capture Systems

Introducing PAF for clinical gait

The Project Automation Framework (PAF) for QTM is the all new infrastructure that let's you automate repetitive tasks in your workflow.

- Automated report generation
- Ability to create custom packages
- Full QTM integration

You are welcome to our booth for a demo.