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# The Application of Gait Analysis in Orthotics

## by Robert S. Lin, C.P.O.

A gait analysis laboratory is an invaluable tool in the quantitative analysis of orthotic systems and their effect on human locomotion. This is particularly true in cases where the orthotic design is based on biomechanical behavior of the extremity during gait, as in the anterior floor reaction orthosis, the posterior offset knee mechanism and the Scott-Craig orthoses.

Traditionally, the success or failure of an orthosis has been based on clinical observation by the orthotist, physician or therapist, while relying on the latest medical record entry and their recollection of the patient's status. Even the most comprehensive dictations often fail to note important subtle factors.

On the other hand, a gait lab report provides a formal permanent record of the specific gait status of an individual. This detailed analysis can be reviewed any time.

Clinical application of the gait laboratory is best demonstrated in the management of an 11 year old spastic diplegic at Newington Children's Hospital. M.C. came to us with hip flexion contractures, bilateral knee flexion contractures, and equinovarus deformities of both feet. Despite these lower extremity contractures, he is ambulatory, exhibiting a markedly tenuous gait pattern and unable to stand in place.

Computerized gait analysis was performed pre-op and ten weeks post-op with and without the anterior floor reaction orthoses. In addition to the stick figures and ground reaction data, linear measurement of single stance percentage, stride length, walking velocity, and external work of walking were all obtained.

These results provided quantitative pre-op, post-op, and post-op with orthoses data which compared specific differences in gait behavior and the effects of surgery and orthotic management on these.

In addition to comparative studies of pre-op, post-op and post-op with orthoses conditions,

| Estimated External Work of Walking (joules/kg/meter) | | |
|---|---|---|
| Preop. | Postop. Braces | Postop. No Braces |
| 1.118 | 0.485 | 0.479 |

**Comparison of data from gait analysis of M.C.**

gait analysis can effectively perform comparative studies between two different orthotic designs, as well as two different orthoses of the same design. A recent study performed on a 30 year old female, with poliomyelitis and unilateral lower extremity involvement, compared various orthotic configurations.

# INTERPRETATION AND DISCUSSION OF DATA

## *History*

Ms. Jones is a 29 year old female with a history of poliomyelitis at age two. The patient was left with lower extremity weakness but was an independent ambulator. Approximately five years ago, the patient sustained a right comminuted supra-condylar fracture which required closed reduction and casting. The patient had a long recovery and rehabilitation time and is still engaged actively in physical therapy. At this time she utilizes a double right metal KAFO and a cane for walking. She recently obtained a floor reaction orthosis, but is able to use this for only a brief time while walking during therapy. Her principal complaint with this floor reaction brace is that she fatigues much more quickly than with her metal KAFO. The Gait Analysis Laboratory assessed the patient's ambulation with her existing orthoses. While the patient's physical therapist and the patient relate significant improvement in both motion strength and endurance in the intervening four years, they are concerned about improving endurance.

## *Comments on Linear Measurements*

The patient has an asymmetrical single stance time and her right step lengths are consistently longer throughout testing. The patient's stride length and velocity increased in these modes: shoe only (no orthosis), floor reaction orthosis, and metal KAFO, respectively. Her best gait in terms of linear measurements approximates only 50 percent of normal walking velocity.

# RIGHT LOWER EXTREMITY

## *Coronal Plane*

The right pelvis is down 5–10 degrees in pelvic obliquity and the right hip is held predominantly in 15–20 percent of abduction. (Knee) Varum-valgum is normal. With the floor reaction orthosis on, both pelvic obliquity and hip abduction are reduced by approximately five degrees. With the KAFO on, both pelvic obliquity and hip abduction are increased.

## *Transverse Plane*

With the floor reaction orthosis, pelvic rotation is normal, hip rotation is slightly external, and knee rotation is significantly normalized. Foot rotation is skewed toward five degrees of internal rotation. With the KAFO on, pelvic rotation is unchanged. There is a marked change in hip rotation, being 20–30 degrees externally rotated. Knee rotation is neutral and motion, as expected, is eliminated, as is foot rotation.

| Linear Measurements—M.C. | | | | | | |
|---|---|---|---|---|---|---|
| | Right Side (11/11/82) | | | Left Side (11/11/82) | | |
| | Preop. | Post-op Braces | Post-op No Braces | Preop. | Post-op Braces | Post-op No Braces |
| Single Stance (%) | 34.48 | 31.25 | 23.08 | 34.48 | 34.47 | 26.83 |
| Step Length (cm) | 37.30 | 39.70 | 37.80 | 44.60 | 48.40 | 41.20 |
| Walking Velocity (cms/sec) | 83.5 | 78.41 | 53.89 | 83.55 | 78.41 | 53.89 |

## LEFT LOWER EXTREMITY

### *Coronal Plane*

The left hip is consistently hiked 5–10 degrees and is in 15 degrees of adduction (from her leg length discrepancy). (Knee) Varum-valgum is normal. The floor reaction orthosis does not significantly change her pelvic obliquity or hip ab-adduction. With the KAFO on, she demonstrates a mild decrease in pelvic obliquity and hip adduction.

### *Sagittal Plane*

Pelvic tilt is off the graph $30^{+}$ degrees. Hip flexion-extension has a fairly normal excursion and is increased approximately 10 degrees. The knee is mildly hyperextended during stance and has good excursion during swing phase. The patient demonstrates a mild drop-foot during swing phase. The patient's AFO does not change her pelvic tilt, hip flexion-extension, knee flexion-extension, nor foot plantar-dorsiflexion significantly. However, the patient's KAFO does significantly decrease her pelvic tilt and hip flexion-extension or foot plantar-dorsiflexion on that side.

### *Transverse Plane*

Pelvic rotation is essentially normal. There tends to be slightly more external rotation at the hip. Knee and foot rotation are essentially normal. The rotational plots are not significantly altered by either the ankle-foot orthosis or the metal KAFO.

## RECOMMENDATIONS

Although the patient appreciates the floor reaction orthosis as it is more cosmetically acceptable, it is obvious that she will need the use of her cane to minimize her energy requirements. It was recommended that a new floor reaction orthosis be fitted to improve the overall gait and possibly increase her endurance.

## DISCUSSION

The patient returned for a repeat gait analysis so we could analyze the efficiency of the new floor reaction orthosis and shoe that she acquired after a gait analysis on October 3, 1984. In addition to the new AFO, the patient ac-

**Summary of Linear Measurements—Jones**

| | J00;1 Left cane, shoes | J01 Left cane, right floor reaction. brace | J02 Left cane, right KAFO | Normal Adults |
|---|---|---|---|---|
| R. Single Stance (%) | 28.26 | 31.71 | 31.82 | 35.07 |
| L. Single Stance (%) | 30.43 | 34.15 | 38.64 | 35.07 |
| R. Step Length (cm) | 42.40 | 38.10 | 57.90 | 65.14 |
| L. Step Length (cm) | 27.00 | 38.20 | 38.10 | 65.14 |
| Stride Length (cm) | 70.45 | 75.65 | 94.90 | 130.29 |
| Cadence (S/min) | 76.60 | 85.71 | 80.00 | 108.24 |
| Walking Velocity (cms/sec.) | 44.97 | 54.04 | 63.27 | 117.42 |

**Summary of Linear Measurements—Jones**

| | J10 New AFO | J11 Old AFO | Normal Adults |
|---|---|---|---|
| R. Single Stance (%) | 23.1 | 25.9 | 35.07 |
| L. Single Stance (%) | 34.0 | 29.8 | 35.07 |
| R. Step Length (cm) | 30.7 | 27.7 | 65.14 |
| L. Step Length (cm) | 33.0 | 34.3 | 65.14 |
| Stride Length (cm) | 63.5 | 61.6 | 130.29 |
| Cadence (S/min) | 69.3 | 61.5 | 108.24 |
| Walking Velocity (cms/sec.) | 36.6 | 31.6 | 117.42 |

quired new tennis shoes with the right one having approximately a 5/8" buildup on the entire heel. Subjectively, the patient stated that she is encouraged by the use of this new AFO and is both comfortable and functional; however, she still fatigues easily and she does not have total confidence in the orthosis.

## SUMMARY

The purpose of this gait analysis was to evaluate the effectiveness of the new floor reaction orthosis. The orthosis still allowed too much knee flexion during stance phase, and although the patient was happy with the orthosis subjectively and it had increased her endurance, it could still be fine-tuned further. The orthosis itself is adequate but the shoe platform could be modified in one of two ways:

1) The heel could be made of a much softer material similar to a SACH heel shock absorber, thus effectively allowing her more plantarflexion and increase in the efficiency of the extension couple.
2) Alternately, the heel could be ground down, removing some of the lift.

It was decided to treat the shoe much like a SACH heel cushion of a prosthesis, and add further cushion in order to allow the orthosis to become more effective in the face of her inadequate quadriceps.

## CONCLUSION

This comprehensive report is a compilation of the data generated and the physician's interpretation of this data. It is obvious that such a report gives the clinician a patient picture that is far superior to all other available documentation. It also enables the progress to be quantified and compared numerically to previous analyses run either pre-op or with different orthotic applications.

The gait analysis laboratory can be used as an adjunct to empirical clinical observation in assisting the orthotist in many of the important decision-making processes. It can reduce the level of "artistry" that is presently a significant component in orthotics, while introducing a level of science to the orthotic design and prescription process.

With this clinical tool, the complex orthotic problems we face daily can be better analyzed as the abnormalities of gait are monitored, documented, and interpreted by the orthotist and physician using the laboratory.

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