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Sensitivity of the OLGA and VCM models to erroneous marker placement: Effects on 3D-gait kinematics

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ABSTRACT

Gait data need to be reliable to be valuable for clinical decision-making. To reduce the impact of marker placement errors, the Optimized Lower Limb Gait Analysis (OLGA) model was developed. The purpose of this study was to assess the sensitivity of the kinematic gait data to a standard marker displacement of the OLGA model compared with the standard Vicon Clinical Manager (VCM) model and to determine whether OLGA reduces the errors due to the most critical marker displacements. Healthy adults performed six gait sessions. The first session was a standard gait session. For the following sessions, 10 mm marker displacements were applied. Kinematic data were collected for both models. The root mean squares of the differences (RMS) were calculated for the kinematics of the displacement sessions with respect to the first session. The results showed that the RMS values were generally larger than the stride-to-stride variation except for the pelvic kinematics. For the ankle, knee and hip kinematics, OLGA significantly reduced the averaged RMS values for most planes. The shank, knee and thigh anterior–posterior marker displacements resulted in RMS values exceeding 10& OLGA reduced the errors due to the knee and thigh marker displacements, but not the errors due to the ankle marker displacements. In conclusion, OLGA reduces the effect of erroneous marker placement, but does not fully compensate all effects, indicating that accurate marker placement remains of crucial importance for adequate 3D-gait analysis and subsequent clinical decision-making.

1. Introduction

Three-dimensional (3D) gait analysis is widely used in clinical gait analyses and research. A 3D-gait analysis provides an objective record of spatio-temporal, kinematic, kinetic, and electromyographic data during gait; it is used to assist clinical decision-making and to evaluate the outcome of therapeutic interventions in patients with walking disabilities found in persons with cerebral palsy, stroke or lower extremity amputations.

To be valuable for clinical decision-making, 3D-gait data need to be reliable. Previous studies have assessed the variability for various study populations including healthy adults [1–5], stroke patients [6], healthy children [7] and children with cerebral palsy [2,7,8] between trials and between sessions conducted by either one or more assessors or by different assessors. A systematic review [9] revealed that the reliability for sagittal and frontal plane kinematics was moderate to high, with the exception of pelvic tilt. In addition, some studies also reported a low reliability for knee varus–valgus kinematics. The reliability of transverse plane kinematics was typically low, with the exception of pelvic rotation. Most studies reported an error of less than 5 for all gait variables, with exception of hip and knee rotation angles [9]. However, substantial variations in gait data exist when the same cerebral palsy patients were evaluated in different laboratories, yielding different treatment recommendations [2].

The variability of the gait data has been attributed to such factors as instrumental errors associated with the motion capture system [10], soft tissue artefacts [11], inherent physiological variability during gait, anthropometric measurement variation, and variation in marker placement. The latter is recognized as the major source of error [1,2,4,5,12]. Variation in marker placement is due to difficulties in identifying broad anatomical landmarks by points and to differences in interpreting instructions. Consequently, the intra-observer variability in the identification of lower extremity anatomical landmarks ranges between 5 and 21 mm and the inter-observer variability ranges between 12 and 25 mm [12,13].

In clinical gait laboratories, the Vicon system (Vicon, Oxford Metrics, London, UK) accompanied by the Modified Helen Hayes model [14] as implemented in the Vicon Clinical Manager (VCM) software is commonly used. This model, however, is highly sensitive to marker placement [15]. Several techniques have been

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