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Reliability of four models for clinical gait analysis

Hans Kainz[a,b,c,d,*], David Graham[a,b], Julie Edwards[c], Henry P.J. Walsh[c], Sheanna Maine[c], Roslyn N. Boyd[e], David G. Lloyd[a,b], Luca Modenese[f,g], Christopher P. Carty[a,b,c]

[a] School of Allied Health Sciences, Menzies Health Institute Queensland, Griffith University, Gold Coast, Australia
[b] Centre for Musculoskeletal Research, Menzies Health Institute Queensland, Griffith University, Gold Coast, Australia
[c] Queensland Children's Motion Analysis Service, Queensland Paediatric Rehabilitation Service, Children's Health Queensland Hospital and Health Services, Brisbane, Australia
[d] Human Movement Biomechanics Research Group, Department of Kinesiology, KU Leuven, Leuven, Belgium
[e] Queensland Cerebral Palsy and Rehabilitation Research Centre, The University of Queensland, Brisbane, Australia
[f] Department of Mechanical Engineering, University of Sheffield, United Kingdom
[g] INSIGNEO Institute for In Silico Medicine, The University of Sheffield, United Kingdom, United Kingdom

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ABSTRACT

Three-dimensional gait analysis (3DGA) has become a common clinical tool for treatment planning in children with cerebral palsy (CP). Many clinical gait laboratories use the conventional gait analysis model (e.g. Plug-in-Gait model), which uses Direct Kinematics (DK) for joint kinematic calculations, whereas, musculoskeletal models, mainly used for research, use Inverse Kinematics (IK). Musculoskeletal IK models have the advantage of enabling additional analyses which might improve the clinical decision-making in children with CP. Before any new model can be used in a clinical setting, its reliability has to be evaluated and compared to a commonly used clinical gait model (e.g. Plug-in-Gait model) which was the purpose of this study. Two testers performed 3DGA in eleven CP and seven typically developing participants on two occasions. Intra- and inter-tester standard deviations (SD) and standard error of measurement (SEM) were used to compare the reliability of two DK models (Plug-in-Gait and a six degrees-of-freedom model solved using Vicon software) and two IK models (two modifications of 'gait2392' solved using OpenSim). All models showed good reliability (mean SEM of 3.0° over all analysed models and joint angles). Variations in joint kinetics were less in typically developed than in CP participants. The modified 'gait2392' model which included all the joint rotations commonly reported in clinical 3DGA, showed reasonable reliable joint kinematic and kinetic estimates, and allows additional musculoskeletal analysis on surgically adjustable parameters, e.g. muscle-tendon lengths, and, therefore, is a suitable model for clinical gait analysis.

1. Introduction

Children with cerebral palsy (CP) have complex musculoskeletal pathologies which are commonly corrected using single-event multi-level orthopaedic surgeries [1]. Three-dimensional gait analysis (3DGA) is used to inform the clinical decision-making in children with CP. Many clinical gait laboratories implement 3DGA methods that estimate joint kinematics and kinetics, but generally do not provide direct objective musculoskeletal information. The surgeon is therefore required to exercise a high level of clinical reasoning to extrapolate the results from 3DGA to develop a surgical plan. In recent years, user friendly musculoskeletal modelling software (e.g. OpenSim [2] and AnyBody [3]) has emerged that additionally enables calculation of muscle-tendon length [4], muscle moment arm [5] and joint contact forces [6]. The adoption of musculoskeletal modelling software for clinical 3DGA may provide additional data to identify musculoskeletal causes of dysfunction, thereby better informing the treatment decision-making process.

Many clinical gait laboratories rely on the conventional gait analysis model [7,8], which employs a computational method termed Direct Kinematics (DK) to calculate joint kinematics. A commonly used variant of the conventional gait model is the Plug-in-Gait (PiG) model, available with the Vicon/Nexus software package. Our confidence in using the conventional gait model is in part due to the demonstrated

* Corresponding author at: Human Movement Biomechanics Research Group, Department of Kinesiology, KU Leuven, Leuven, Belgium, Tervuursevest 101–Box 1501, 3001 Leuven, Belgium.

E-mail addresses: hans.kainz@kuleuven.be, hans.kainz@griffithuni.edu.au, hans.kainz@gmx.net (H. Kainz), david.graham@griffith.edu.au (D. Graham), julie.Edwards@health.qld.gov.au (J. Edwards), john.walsh@mater.org.au (H.P.J. Walsh), sheanna.Maine@health.qld.gov.au (S. Maine), r.boyd@uq.edu.au (R.N. Boyd), david.lloyd@griffith.edu.au (D.G. Lloyd), l.modenese@sheffield.ac.uk (L. Modenese), c.carty@griffith.edu.au (C.P. Carty).

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