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The comparison of normative reference data from different gait analysis services

Ornella Pinzone [a,*], Michael H. Schwartz [b,c], Pam Thomason [d], Richard Baker [a]

[a] University of Salford, UK
[b] Gillette Children's Specialty Healthcare, St. Paul, MN, USA
[c] University of Minnesota, Minneapolis, MN, USA
[d] Royal Children's Hospital, Melbourne, Australia

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ABSTRACT

Comparison of normative data between gait analysis services offers the potential to harmonise data collection protocols. This paper presents a method for such a comparison based on an assumption that the root mean square difference from the inter-service mean is a reflection of systematic differences in protocols and that the average standard deviation includes a component attributable to within-centre measurement variability.

Substantial normative datasets from two highly respected clinical services were compared. The RMS difference for the difference from the inter-centre mean was less than 1.7° for all kinematic variables apart from hip rotation (2.9°) and foot progression (2.1°), less than 0.1 Nm/kg for all joint moments and than 0.21 W/kg for all joint powers. The two centres showed very similar normative standard deviations.

The data demonstrates a high degree of consistency between data from two highly regarded gait analysis services and establishes a baseline against which other services can assess their performance. An electronic appendix includes data to facilitate this comparison.

1. Introduction

In the past it has been considered acceptable for clinical gait analysis services to vary in their data capture protocols and reference datasets were collected to allow for these differences [1–3]. As the clinical gait analysis matures, there is a growing requirement for standardization between services [4,5]. This has been underlined by two articles [6,7] emphasizing the differences between laboratories in 3D gait analysis data, raising concern within the orthopaedic community [8,9]. The rationale for collecting reference datasets in the future should thus be to harmonise protocols through comparison between different services. This study describes a mechanism for such a comparison and illustrates this by comparing data from two internationally regarded gait analysis services.

2. Materials and methods

The normative reference data (means and standard deviations) in routine use at two gait analysis services (Gillette Children's Specialty Healthcare, GCSH, and the Royal Children's Hospital, Melbourne, RCH) were compared. The normative reference data were created using data from 81 patients, with an age range between 4 and 17 years at one centre, and 31 patients, with age between 6 and 17 years at the other centre. All data had been collected at self-selected walking speed, with a Vicon kinematic measuring system (Oxford, UK) and AMTI force plates (Watertown, MA, USA). The lengths of the walkways were respectively 8 m and 15 m. Knee Alignment Devices (KAD) were used in static calibration. Trajectories had been filtered with a Woltring spline filter [10] and then processed using Plug-in Gait [11] software (Vicon, Oxford, UK). Data were sampled to 51 values during the gait cycle; however there is no particular reason to believe this method would be sensitive to this value.

Means (m_{ijt}, i refers to service, j to gait variable and t to % of gait cycle) and standard deviations (S_{ijt}) of the clinically important kinematic and kinetics variables from the two gait analysis services

* Corresponding author. +44 7414758591.
E-mail addresses: O.Pinzone@salford.ac.uk, ornellapinzone@hotmail.it (O. Pinzone).

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were plotted together to visualize the level of agreement (Figs. 1 and 2). Assuming that the two cohorts walked similarly, then differences in the mean measurements reflect systematic differences in measurement technique between the two centres. Although comparing one mean to the other appears an obvious choice for comparisons, each service is interested not in how it compares with the other, but how it compares with the true mean for the population. Given that there is no reason to suspect that one set of measurements is "better" than the other, the grand mean between the services (M_{jt}) is actually the best estimate of the true mean. Given that differences in technique are likely to be characteristic of the service rather than the participants, a simple mean was preferred to a mean weighted by number of participants.

$$M_{jt} = \frac{1}{N}\sum_{i=0}^{N} m_{ijt}$$

where N is the number of services (2 in this case).

Systematic differences were then quantified by considering the difference between the mean for each service and the grand mean $\Delta_{ijt}(= m_{ijt} - M_{jt})$. This approach has the advantage that the method can be extended to the comparison of any number of services.

Three parameters are assumed to be of interest: $RMS\Delta$, $mean\Delta$, and $SD\Delta$.

$$RMS\Delta_{ij} = \sqrt{\frac{1}{n}\sum_{t=0}^{n}\Delta_{ijt}^{2}}$$

$$mean\Delta_{ij} = \sqrt{\frac{1}{n}\sum_{t=0}^{n}\Delta_{ijt}}$$

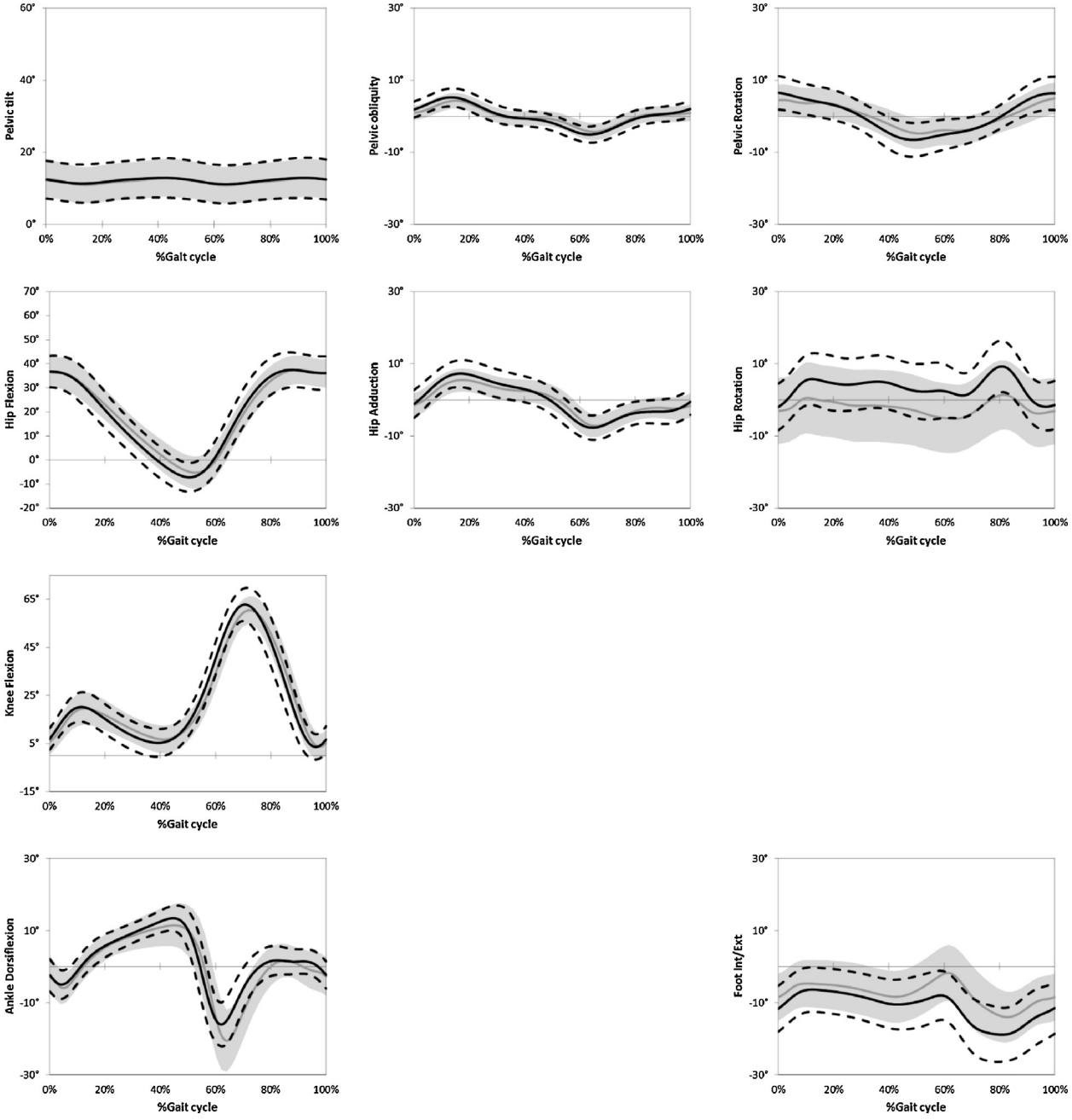

Fig. 1. Mean and standard deviations between GCSH (grey) and RCH (black). Kinematics normative reference data.