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Title: Instrumenting the clinical examination: A proof of concept study

Authors:
Emma Pratt, Wendy Dickens, Amaka C Offiah, Derek Burke, Daniel Hawley

Introduction:
During standard clinical 3D gait analysis, retro-reflective markers are placed on anatomical landmarks to allow kinematic modelling of the lower limb. To interpret this data however, information from a static clinical examination is also required, in order for primary and secondary causes of gait deviations to be determined. Clinical examinations commonly require two clinicians, one manipulating the limb, the other measuring joint ranges of motion (ROM) using goniometry, with reliability of ≤10° accepted within and between assessors[1]. This study presents preliminary work investigating the possibility of measuring joint ROM by tracking retro-reflective markers, with the aim of reducing the time demands on both clinicians and patients, and improving reliability of measurements. As clinical examinations are performed with patients lying supine or prone on a plinth, standard marker positions on the anterior superior iliac spines (ASIS) and sacrum (SACR) to model the pelvis are not possible.

Research Question:
Can pelvic ‘pods’ placed on the lateral pelvis be used to accurately create and track virtual ASIS and SACR markers throughout routine clinical examination movements to assess internal and external rotation at the hip joint?

Methods:
For this proof of concept work, data was collected using 12 Vicon Vantage cameras, processed in Vicon Nexus v2.6.1 using Vicon PlugIn Gait model, from 1 normal adult subject. A coban belt covering the ASIS and SACR was applied before our laboratory’s standard lower limb marker set with two additional two rigid pelvic ‘pods’ was placed laterally on the belt. Code was written in Vicon Bodybuilder (Oxford, UK) to create virtual pelvic markers relative to each lateral pelvic pod. Three standing trials were completed with the subject completing maximal active hip internal and external movements (standing on left leg with right hip and knee flexed to 90°, moving foot medially and laterally), and difference in hip angles calculated from direct markers and virtual markers compared. Direct pelvic markers were then removed, and the subject performed the same hip movements lying prone on a plinth, with the difference in angle calculated with virtual pelvic markers when standing and lying compared. Based on our laboratory’s annual intra- and inter-measurer reliability data, differences of <5° would be deemed acceptable.

Results:

	Standing			Supine	Difference supine v standing (virtual)
	Direct mkr	Virtual mkr	Difference	Virtual mkr	
(R) external hip rotation	-23.1° (0.2)	-19.6° (0.8)	3.5°	-18.3° (2.4)	1.3°
(R) internal hip rotation	16.2° (0.6)	20.6° (0.6)	4.5°	23.7° (1.7)	3.1°

Table 1. Mean (1sd) and difference in maximal external/internal hip rotation modelled using direct pelvic markers vs virtual pelvic markers when standing. Mean (1sd) and difference in maximal external/internal hip rotation modelled using virtual markers when standing vs supine.

Discussion:
Based on this initial work, use of lateral pelvic pods to allow instrumentation of the clinical examination appears feasible; differences in hip rotation calculated with direct and virtual markers were within our laboratory’s acceptable limits for repeatability. Further work is required to further understand which movements can be measured in a similar way when following our laboratory’s standard clinical examination protocols and to assess acceptability and reliability of this method of movement measurement.