Quantification of multi-segmental spine kinematics: The reliability and Outcomes of a new protocol

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Introduction: Motion abnormalities have been found to impact the onset and recurrence of spine disorders [1]; a better understanding of spine kinematics is needed to improve treatment, surgical planning, and assess the role of spine pathologies on activities of daily living (ADL) [2]. Several marker-based motion analysis protocols exist; however, assessment of the reliability and functional significance is lacking for healthy and pathological cohorts. The aim of the present study is to develop and test a comprehensive protocol for spinal kinematics assessment providing clinically significant data. This study includes the assessment of reliability, as well as the identification of kinematics and timing reference patterns during simple mobilization and ADLs.

Methods: The marker setup included 9 markers attached to the trunk to define 4 spine segments: upper thoracic (UT), lower thoracic (LT), upper lumbar (UL) and lower lumbar (LL) in addition to the pelvis and shoulders. 3D angles between adjacent segments and with respect to the pelvis were quantified during simple mobilization tasks (flexion/extension, lateral bending, rotation) and ADLs. Twenty-two healthy participants were recruited [10F, 12M; age: 26.6±4; height: 175.6±7.4cm; weight: 71.1±14.9kg]. Marker kinematics was acquired using stereophotogrammetry (VICON, UK). Sensitivity to marker placement (i.e., subject standing and bent forward) were tested. 3D angular data were normalised over task duration and synchronised with respect to timing of key events (e.g., occurrence of maximal flexion, maximal velocity). Reference bands of motion were defined as median and 25^{th}-75^{th} percentile range.
Results: Differences in intersegmental kinematics resulting from different marker placement approach resulted in up to 25% difference in LT/UL angle during full flexion, and 5% difference in event timing in flexion/extension of during full and thoracic flexion. After event synchronization, angular intersegmental kinematics exhibited high inter- and intra- subject repeatability in both flexion/extension and lateral bending. Segmental timing analysis showed UL/LL starting the motion before UT/LT during full flexion, while the opposite pattern is observed during lateral bending. Differences in segmental ROM showed that UT/LT exhibited the smallest mobility, while UL/LL the highest for all tasks. Differences in the timing of the maximum ROM over the task duration were seen especially during the full flexion task accounting for a maximum of 15% between UT/LT and UL/LL, for the remaining tasks the difference was limited to <5%.
Discussion: The preliminary testing of the proposed protocol highlighted a repeatable approach for the characterisation of spine intersegmental kinematics. Marker misplacement was found to significantly affect intersegmental kinematics to a different extent for different segments. The variability assessed in the study allows to define the significant number of subjects that must be included in the reference cohort of healthy subjects, in this case to reach the 80% confidence level a total of 30 participants are needed for the analysis.

References:

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