QUANTIFICATION OF MULTI-SEGMENTAL SPINE KINEMATICS: THE RELIABILITY AND OUTCOMES OF A NEW PROTOCOL

Jennifer Fayad (1,2), Peter Eltes (2), Aron Lazary (2), György Szőke (3), Tamás Terebessy (3) Luca Cristofolini (1), Rita Stagni (4)

1. Department of Industrial Engineering, Alma Mater Studiorum – Università di Bologna; 2. National Centre for Spinal Disorders, Budapest; 3. Department of Orthopaedics – Semmelweis University, Budapest; 4. Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi", Alma Mater Studiorum – Università di Bologna

Introduction: Motion abnormalities have been found to impact the prevalence and recurrence of spine disorders; a better understanding of spine kinematics is necessary to improve treatment, surgical planning and assess the role of spine pathologies on activities of daily living (ADL). Several marker-based motion analysis protocols have been proposed however, assessment of the reliability and functional significance of the kinematic variables is lacking for healthy and pathological cohorts. Additionally, the role of coordination between spinal segments, and with respect to other body segments is often disregarded. The aim of the present study is to fill this gap: to develop and validate a comprehensive protocol for spinal kinematics assessment that provides clinically significant data. This study included experimental assessment of methodological reliability, identification of kinematics reference patterns and timings during simple mobilization and ADLs.

Methods: The marker setup included 9 markers attached on the trunk at C7, T3, T7, T12, L3, clavicle, sternum, right and left acromia; to define four spine segments: upper thoracic (UT), lower thoracic (LT), upper lumbar (UL) and lower lumbar (LL) in addition to the pelvis. 3D angles between adjacent segments and in respect to the pelvis were quantified during standing, full flexion (FF), thoracic flexion (TF), lateral bending (LB), sit-to-stand, ball-lifting, and level walking. 19 healthy participants were recruited [10F, 9M; age: 26.6±4; height: 175.6±7.4cm; weight: 71.1±14.9kg]. Marker kinematics was acquired using stereophotogrammetry (VICON, UK). Two marker placement techniques were tested to quantify soft tissue artefact (STA) and marker misplacement. 3D angular data was normalised over task duration and synchronised with respect to key events identified in the motion to analyse segment coordination and event timing. Reference bands of motion were generated showing the median angle and the 25^{th}-75^{th} percentile range.

Results: Differences in intersegmental kinematics were found due to marker placement and STA accounting for a maximum of 25% change in the LT/UL angle during TF. The maximum difference in key event timings was equal to 5% change in the coronal plane during LB, changes in the sagittal plane were limited to <2% for FF and TF. After event synchronization, angular intersegmental kinematics exhibited high inter- and intra- subject repeatability in both flexion/extension and lateral bending. Segmental coordination analysis showed differences in the timing of segments with UL/LL starting the motion before UT/LT during FF, the opposite was seen during LB. Differences in motion contribution were also seen, LT/UL contributed the most to the sagittal plane motions accounting for double the angle of motion detected at the UT/LT joint.

Conclusion: The preliminary testing of the proposed protocol highlighted a repeatable approach for the characterisation of spine intersegmental kinematics. Marker misplacement and STA were found to influence intersegmental kinematics to a different extent for different segments. Based on the variability assessed in the study, the number of cohorts for the identification of significant reference bands will be increased and compared to pathological patient motion.