EVALUATION OF A POSTURAL MONITORING TOOL FOR PAEDIATRIC SPINAL DEFORMITIES

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INTRODUCTION

Idiopathic Scoliosis (IS), is a class of paediatric spinal deformities that has historically posed a significant challenge to the orthopaedic and scientific community. Current clinical models of assessment consider age, gender, skeletal maturity, family history and radiological measures (curve amplitude, location, and side) as the primary indicators for treatment [1]. These factors are typically measured during the regular follow-up of the child, and guide decisions related to the timing and type of treatment. However, these clinical measurements provide limited insight into the biomechanical and neuromuscular factors that contribute to the alignment and stability of the spine and how they relate to outcomes such as physical function, activity and mobility. There is an emerging recognition that new insight may be gained by expanding current observational techniques beyond the clinic. Technological innovations and advancements in analytical techniques have provided a unique opportunity to develop measurements of neuromuscular function and spinal stability that may be associated with activity and participation. This provides a new avenue to understand the intrinsic and extrinsic determinants of spinal stability and develop new measures that can enhance our understanding of the natural history and the effectiveness of treatment interventions for children living with a spinal deformity.

The objective of this pilot project is to evaluate the feasibility of implementing a wireless ambulatory monitoring technology that will assess the duration and frequency of asymmetric postures that are assumed during the engagement of activities that are reflective of every-day life.

METHODS

Participants: An initial cohort of 10 able bodied adult participants were recruited to participate in this pilot study.

Instrumentation: Each participant was evaluated in the Biomechanics and Assistive Technology located in the Rehabilitation Sciences Building at the University of Toronto. This laboratory is equipped with a multi-camera Vicon Mx motion capture system, a 16 Channel Delsys Myomonitor IV portable wireless EMG system, and a multi-axial AMTI force plate.

Protocol: Upon arrival in the laboratory participants provided written informed consent. Each participant underwent a standardized evaluation that consisted of 1) Anthropometric Landmark Detection and placement of Reflective Markers on the lower extremities, pelvis, trunk, head and arms. 2) Placement of 2 tri-axial accelerometers (Sacrum and T1). 3) Placement of EMG electrodes on the lumbar, thoracolumbar and thoracic paraspinal muscles. Following the set up procedure an upright standing reference posture was acquired with the Vicon system, followed by standard reference contractions for the paraspinal muscles. Participants then performed a series of standardized movements in the laboratory and a continuous set of out of laboratory activities. The in-laboratory tasks included quiet standing and sitting, active lateral trunk flexion and walking. This continuous bout of activity included walking, stairs, sitting at a work station, and ‘slouched’ sitting for approximately 5 minutes each.

RESULTS

Postural Modeling: Initial analysis is focused on the application of a model that will facilitate the accurate measurement of the Centre of Mass (COM) of the individual in a seated and standing position. Figure 1 presents the COM estimated from a force plate (COMFP) and that estimated from a standard link segment kinematic model for 1 participant [2]. Visual inspection of the COM trajectory reveals similar spatial and temporal characteristics. However, importantly, the kinematic model over-estimates COM trajectory at the end range of a movement (ie., full anterior-flexion, full lateral flexion).

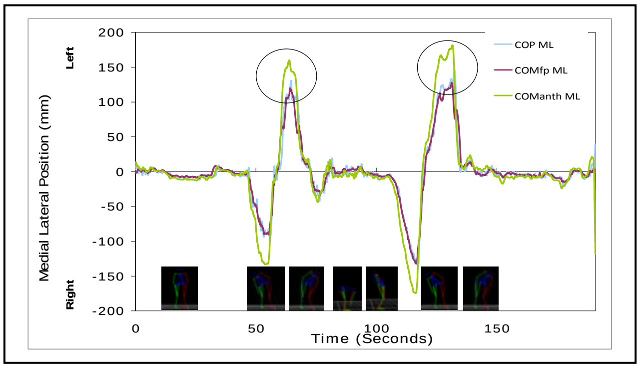

Figure 1: Medial Lateral displacement of the COM. Note the significant deviations during lateral flexion.

Continuous Postural Monitoring: Initial analysis of the ambulatory monitoring data is focused on the identification of bouts of muscle activity/inactivity, accelerations and global posture of the trunk. Figure 2 presents bouts of walking, stairs, sitting at a work station and slouching for 1 participant. As expected, these activities revealed clear phasic activity of the paraspinals, with minimal activity during sitting and slouched sitting.

Figure 2 : Muscle activity of the paraspinal and multifidus.

Figure 3 (A) represents sample accelerometer information within smaller temporal windows of the continuous activity set. The spatial and temporal pattern of vertical, anterior-posterior and medial lateral accelerations of the trunk are typical of those previously reported in the literature. Figure 3(B) demonstrates a change in accelerometer signal that is reflective of a transition from an upright sitting posture to a 'slouching' posture.

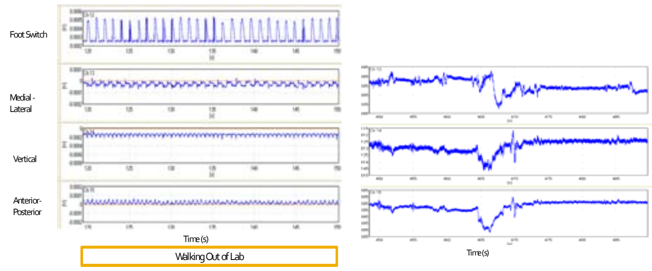

Figure 3: Sample trunk accelerometer data when walking (A: left) and when sitting and 'slouching' (B:right).

CONCLUSION

This preliminary pilot study has revealed the feasibility of acquiring postural data during the performance of continuous activities such as walking and seated activities. Ongoing work is focused on the analysis of the initial cohort of 10 able bodied adult subjects, validating the accelerometer data with motion capture and the development of algorithms to analyze the amplitude and frequency components of trunk accelerations within each type of activity.

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