Time-series analysis of two multi-segment spine models to assess movement in adolescent idiopathic scoliosis

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Summary

This study aimed to examine the effect of two kinematic models on multi-segment spine movement in adolescent females with scoliosis, using statistical parametric mapping analysis. Significant differences were evident in some segment angles across the spine segments and the three planes of motion during the stance phase of gait. Differences may be explained by the kinematic modelling approach and the surface topography and morphological factors of the patients.

Introduction

Multi-segment spine modelling enables insight into the complex movement of the scoliotic spine during gait. However, as several models exist [1,2], it is vital to know the differences in time-series segment angles between models if the associated data is used to direct clinical interventions. This study compared the segment angle time-series waveforms from two multi-segment spine models during gait in patients with Adolescent Idiopathic Scoliosis (AIS).

Methods

Following ethical approval, ten female participants (14±1.5 years, 1.66±3.6 m, 53.5±9.6 kg) with AIS were recruited. Marker trajectory data was collected at 100 Hz using a 10-camera motion capture system (Vicon, Oxford, UK). Reflective markers were attached to the spine and back in accordance with Model 1 (M1) [1] and Model 2 (M2) [2]. Participants walked barefoot at their preferred walking speed (PWS: 1.09m/s±0.13) and fast walking speed (FWS: 1.44±0.15 m/s). Segment angle data from 5 trials were time-scaled, normalized to 100% of the stance phase and analysed using time-series waveforms. Statistical parametric mapping (SPM) [3] was used to compare angles of the upper and lower thoracic and lumbar spine segments.

Results and Discussion

SPM analysis revealed significant differences between M1 and M2 across some spinal segments and planes of motion during the PWS and FWS condition. For example (Figure 1), M1 demonstrated a significant increase in flexion in the lower lumber region in the sagittal plane between 0 and 45% of stance in the PWS condition. In addition, increased flexion was noted throughout stance. However, this increased flexion offset did not exceed 2.5° and both models displayed similar kinematic waveform profiles (Figure 1a). A comparable observation was noted in frontal plane between 0 and 24% of stance, with M1 demonstrating greater lower lumbar lateral flexion to left (Figure 1c). While SPM analysis did not show any significant differences between M1 and M2 in the transverse plane, kinematic waveform profiles were different between models across the entire stance phase (Figure 1e). Since M1 includes individual markers on the lateral surface of the back, soft tissue artefact, skin elasticity and body composition may impact on angle outputs in comparison to M2, which is 3D cluster located over L3.

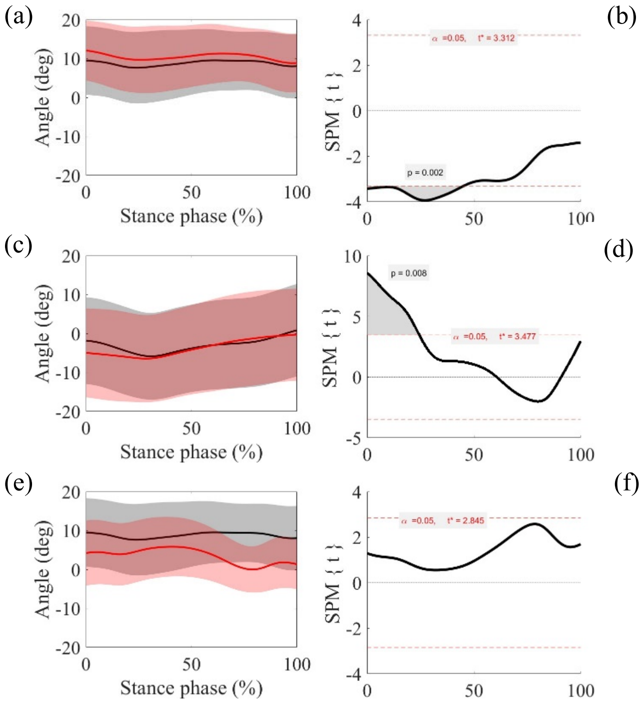

Figure 1: Lower lumbar segment angles in the sagittal (a), frontal (c) and transverse (e) plane for M1 (black) M2 (red), and SPM results (b, d, f).

Conclusions

Understanding the kinematic modelling approach along with surface topography and morphological factors are essential for interpretation of the reported segment angles employed in gait analysis in patients with AIS.

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References

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