A SCOLIOSIS ANALOG MODEL FOR THE EVALUATION OF BRACING TECHNOLOGY

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INTRODUCTION
Thoracolumbar braces are commonly used to treat Adolescent Idiopathic Scoliosis (AIS). Braces serve to reduce and prevent progression of the spinal curve by applying corrective forces. Recent publications of monitored brace wear have demonstrated a braces ability to control curve progression and prevent the need for spinal fusion surgery (1). However, the magnitude and direction of these corrective forces applied by a brace to the spine remain unknown. The objective was to design and validate an analog model of a mid-thoracic single curve scoliotic deformity for quantifying structural properties of the brace and the brace force response. The model was used to investigate strap-related brace design alterations.

METHOD

Apparatus: A novel, mechanically-equivalent analog model of the AIS condition was designed and developed to simulate up to 40° of spinal correction (Figure 1). The linkage-based model was used with a biorobotic testing platform to test a scoliosis brace.

Procedures: For the purpose of the initial validation phase, the brace was tested using two types of straps (Velcro and buckle) applied in various configurations (1,2,3,4 velcro straps; 1,2,3 buckle straps) and compared to unconstrained and rigidly constrained configurations to demonstrate the capacity of the model to study brace design alterations.

Data Analysis: Measurements of the force components applied to the model and angular displacement of the linkage assembly were used to calculate the brace structural stiffness properties. Differences in mean stiffness values within and between configurations were compared using a one-way ANOVA and ranked using Tukey’s post hoc test.

RESULTS
Calculated stiffness (N/deg) was expressed as a resistive force (N) relative to the angular change (Deg) of the linkages (Table 1). Either strap type significantly increased the stiffness values relative to the unconstrained configuration. An optimal brace radial stiffness was achieved with three Velcro straps, i.e., no significant stiffness gained by adding a fourth strap. For the buckle straps, no significant stiffness gain occurred when more buckle straps were added.

DISCUSSION
Structural properties provide a means to compare bracing technology and better understand design features. The testing of design alterations, i.e., variable strap configurations, show a measureable difference in brace force response and structural properties between each configuration. Also, interpretation of the measured force components revealed that the brace applied inward and upward forces to the spine.

CONCLUSION
A novel scoliosis analog model and testing assembly were developed to provide first time measures of the forces applied to the spine by a thoracolumbar brace. In addition to quantifying brace structural properties, this test assembly could be used as a design and testing tool for scoliosis brace technology.

CLINICAL APPLICATIONS
This Scoliosis Analog Model will provide a platform to test and quantify the forces generated by a scoliosis brace which will allow for improvements in brace design and efficacy.

REFERENCES

Figure 1. Schematic representation of the Scoliosis Analog Model prior to attachment to the biorobotic testing platform and prior to application of the brace.

Table 1. Mean Radial and Axial Stiffness Values.