Feasibility of a Novel Axial Traction Device for Measuring Spinal Stiffness in Scoliosis Patients

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Summary

An EOS-compatible spinal traction device for assessing spinal stiffness was developed and evaluated. The device applied controlled axial traction with minimal muscular interference, supporting its potential use in both research and clinical settings.

Introduction

Spinal stiffness, defined as the spine's resistance to deformation under an applied force, is a critical parameter in planning spinal fusion procedures and developing patient-specific computational spine models. These models aid in understanding the biomechanics of spinal deformities, such as idiopathic scoliosis [1]. One approach to assessing spinal stiffness involves applying an axial traction force to the spine and quantifying its deformation using biplanar radiographic imaging [2]. The low-dose EOS imaging system (EOS imaging SA, Paris, FR) provides a suitable platform for this measurement and minimizes radiation exposure. However, the muscular response to axial traction remains poorly understood. This study aimed to develop and evaluate an EOS-compatible device for applying axial traction to the spine and assess its feasibility by quantifying trunk muscle activation during traction in a healthy adolescent.

Methods

An EOS-compatible spinal traction device was developed, consisting of a mechanical frame with a head halter and a motorized scissor jack system with a force-sensor-instrumented platform for patients to stand on (Fig. 1A).

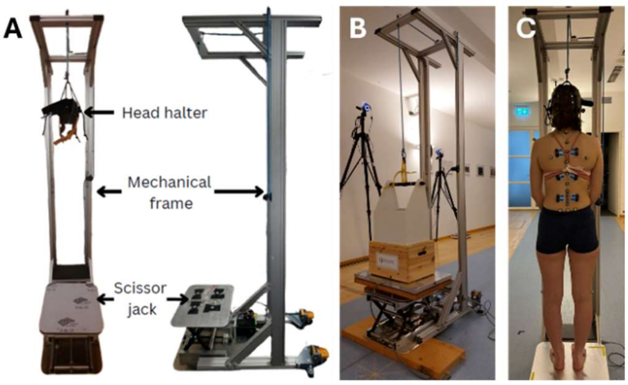

Figure 1: A) Spinal traction device, B) experimental setup for evaluating its accuracy, and C) experimental setup for evaluating muscle activity during axial traction in a 14-year-old girl.

The accuracy of the device was evaluated with a weight of about 500N by comparing the applied traction (30% weight reduction) and the platform's downward displacement, as measured by the traction device and reflective markers on the traction device (Fig. 1B). Feasibility was assessed by recording trunk muscle activity in a healthy 14-year-old girl while gradually increasing the applied traction force up to 30% of her body weight (Fig. 1C). Muscle activity was measured using an 8-channel surface electromyography system (Cometa, Barreggia, IT).

Results and Discussion

The applied traction to the 500 N weight resulted in a median weight reduction of 30.2% (range: 1.4%) and 32.3% (1.2%), with corresponding platform displacements of 65.5 mm (5.9 mm) and 62.9 mm (5.7 mm), as measured by the traction device and the Vicon system, respectively (Fig. 2). These results demonstrate the device's accuracy in applying controlled axial traction. Muscle activity during full traction (30% of body weight) remained comparable to pre-traction levels (Fig. 2), suggesting that the participant was able to relax the trunk muscles during traction.

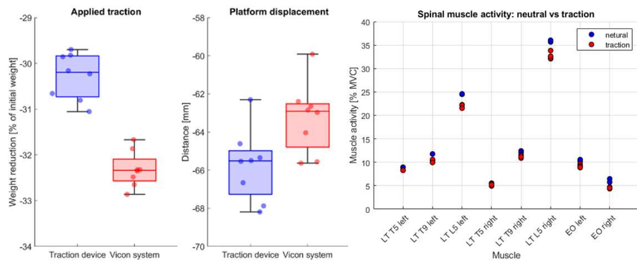

Figure 2: Left: Applied traction and platform displacement measured with traction device and Vicon system. Right: Activity of bilateral longissimus thoracic (LT) and externus obliquus (OE) muscles with (5 trials) and without traction (neutral, 2 trials).

This finding supports the feasibility of the device for assessing spinal stiffness without significant muscular interference. The ability to apply traction while maintaining minimal muscle activation is crucial for isolating passive spinal properties.

Conclusions

The device enables controlled axial traction, providing a promising tool for investigating spine biomechanics in both healthy individuals and patients with spinal deformities.

Acknowledgments

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References

[1] Rauber et al. (2024). *J Biomech*, **163**: 111922.
[2] Büchler et al. (2014) *Eur Spine J*, **23**:2619-25.