

Motion capture-driven simulations of spinal motion in patients with scoliosis

Background Adolescent idiopathic scoliosis (AIS) is a complex 3D spinal deformity, in which vertebral growth is altered by pathologic biomechanical forces acting on the vertebral growth plates. When the scoliosis deformity progresses to a Cobb-angle beyond 45°-50°, surgical spinal fusion is required, which results in a stiffer spine and is associated with various complications. To avoid such invasive procedures, it is important to stop the progression of the curve as early as possible through conservative treatments such as scoliosis-specific exercises (SSE).

The effectiveness of currently practiced SSE is low, and new approaches should be considered. Before conducting complex clinical trials, however, new exercise concepts should be evaluated using biomechanical simulations. For this reason, we previously developed musculoskeletal (MSK) models with a fully articulated thoracolumbar spine and rib cage,¹ implemented spinal deformity and simulated spinal motion during functional activities in patients with AIS.² However, since these models were built using simple geometrically-determined joint center locations and did not include any kinematics constraints, the accuracy of these simulations remains uncertain.

This master thesis aims to add kinematic constraints to the model, restrict the movements of the model's bodies to physiological ranges of motion, and to systematically investigate how variations in joint center definitions and the implementation of kinematic constraints influence the accuracy and robustness of spinal motion simulations during functional activities.

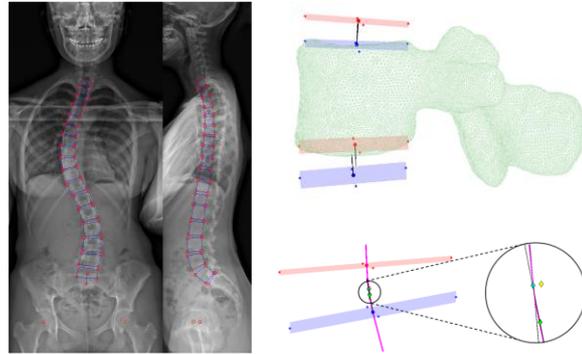


Figure 1: Extraction of the spinal deformity and determination of joint center locations.

Materials and Methods As a basis, you will use MSK models developed from radiographic and motion capture data of AIS patients obtained within an ongoing project funded by the Swiss National Science Foundation (SNSF; <https://data.snf.ch/grants/grant/214986>). You will then examine the sensitivity of spinal motion simulations to different joint center definitions and kinematic constraint implementations in AIS patients performing various functional activities.

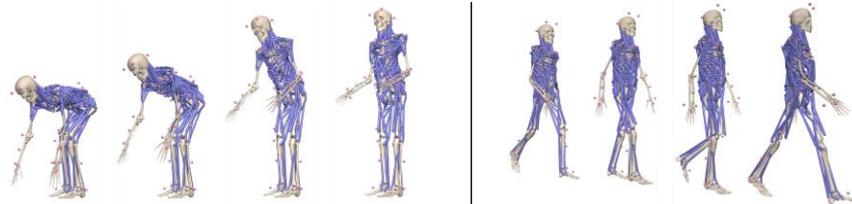


Figure 2: Kinematic simulations of a box lifting task (left) and walking on a level ground (right).

References

- Schmid S, Burkhart KA, Allaire BT, Grindle D, Anderson DE. J Biomech. 2020;102:109305.
- Rauber C, Lüscher D, ..., Büchler P, Schmid S. Journal of Biomechanics. 2024;163:111922.

Nature of the Thesis:

Literature reviews: 10%
 Establish and implement different joint center locations and kinematic constraints: 50%
 Sensitivity studies: 30%
 Documentation: 10%

Requirements:

- Interest in biomechanics, medical image processing, and computational modeling
- Programming skills in MATLAB/Python, experience with OpenSim an advantage

Supervisors:

Prof. Dr. Stefan Schmid
 Prof. Dr. Philippe Büchler

Institutes:

Spinal Movement Biomechanics Group, Bern University of Applied Sciences, Physiotherapy Research, www.bfh.ch/smb-group

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