

Personalizing musculoskeletal spine models of 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 and implemented spinal deformity for patients with AIS.² However, since these models were built based on morphologic data from the literature, they lack personalization of various parameters such as trunk mass distribution and muscle geometry.

To address this issue, this master thesis aims at the implementation of personalized trunk mass distribution and muscle geometry/force capacity parameters derived from medical imaging data.

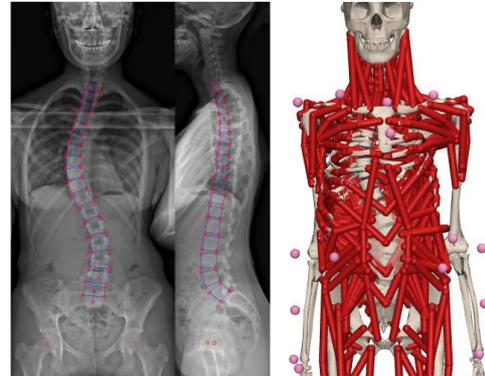


Figure 1: MSK model of the scoliotic spine

Materials and Methods You will use magnetic resonance imaging (MRI) data of AIS patients, which were collected in the context of an ongoing project funded by the Swiss National Science Foundation (SNSF; <https://data.snf.ch/grants/grant/214986>). Based on previously proposed approaches,^{3,4} you will extract the relevant parameters and implement them into the MSK models. In a final step, you will conduct sensitivity studies to evaluate the impact of personalization.

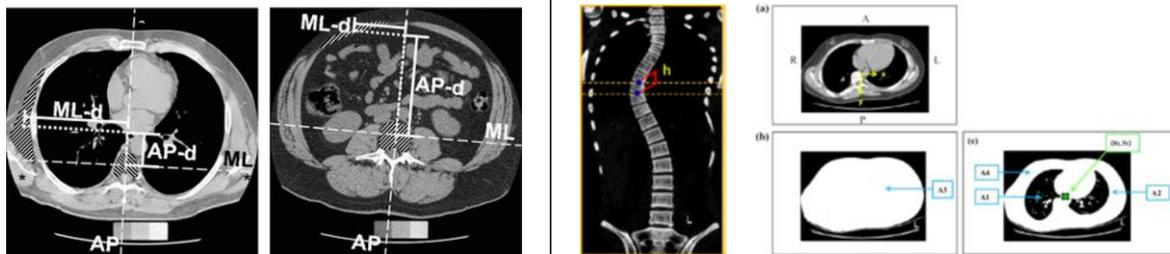


Figure 2: Left: Segmentation of muscle cross-sectional areas.³ Right: Extraction of segmental centers of mass.⁴

References

1. Schmid S, Burkhart KA, Allaire BT, Grindle D, Anderson DE. J Biomech. 2020;102:109305.
2. Rauber C, Lüscher D, ..., Büchler P, Schmid S. Journal of Biomechanics. 2024;163:111922.
3. Anderson DE, D'Agostino JM, Bruno AG, Manoharan RK, Bouxsein ML. J Biomech. 2012;45(1):66-75.
4. Keenan BE, Izatt MT, Askin GN, Labrom RD, Pettet GJ, Percy MJ, Adam CJ. Clin Biomech (Bristol, Avon). 2014;29(7):773-779.

Nature of the Thesis:

Literature reviews: 10%
Image processing and parameter extraction: 30%
Implementation into MSK model: 30%
Sensitivity studies: 20%
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

ARTORG Center for Biomedical Engineering Research, Computational Bioengineering, www.artorg.unibe.ch/research/cb

Contact: Prof. Dr. Stefan Schmid, stefan.schmid@bfh.ch, Tel. +41 31 848 37 96