Enhancing a musculoskeletal full-body model with a thoracolumbar fascia to improve spinal loading simulations in scoliosis patients

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) full-body models with a fully articulated thoracolumbar spine and rib cage. However, since the models do currently only contain active structures (i.e., muscles), effects resulting from the deformation of passive structures such as joint capsules, ligaments, and fasciae are not considered. To compensate for this, we use artificial torque generators, but these do most likely not reflect true soft tissue contribution.[1] One prominent passive structure is the thoracolumbar fasciae, which plays an important role in the load transfer between the trunk and the limbs, particularly during forward-bent activities such as object lifting.

Aim 1) To enhance the current MSK full-body models with a thoracolumbar fascia, and 2) to evaluate the effects of the thoracolumbar fascia on spinal loading simulated for various functional activities in scoliotic patients.

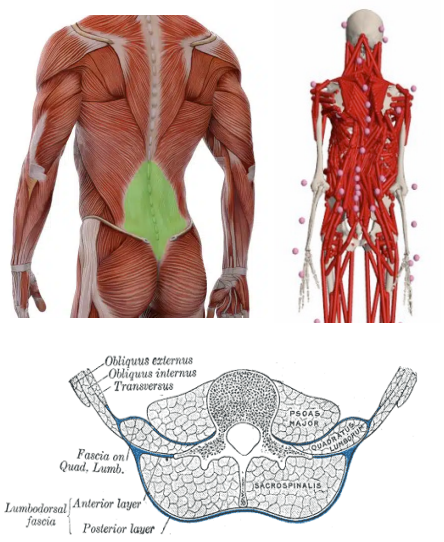

Figure 1 Graphical representation of the thoracolumbar fasciae in the atlas and the cross-sectional area. Additionally, an overview of the currently used MSK model personalized for an AIS patient.

Materials and Methods As a basis, you will use an Opensim[2]-based generic MSK full-body model, which was previously adapted for children aged 12-18 years.[3] The implementation of the thoracolumbar fascia as well as the simulations will be conducted using MATLAB or Python.

References

1. Rauber C, Lüscher D, Poux L, et al. Predicted vs. measured paraspinal muscle activity in adolescent idiopathic scoliosis patients: EMG validation of optimization-based musculoskeletal simulations. *Journal of Biomechanics*. 2024;163:111922. doi:10.1016/j.jbiomech.2023.111922
2. Delp SL, Anderson FC, Arnold AS, et al. OpenSim: Open-Source Software to Create and Analyze Dynamic Simulations of Movement. *IEEE Trans Biomed Eng*. 2007;54(11):1940-1950. doi:10.1109/TBME.2007.901024
3. Schmid S, Burkhart KA, Allaire BT, Grindle D, Anderson DE. Musculoskeletal full-body models including a detailed thoracolumbar spine for children and adolescents aged 6-18years. *J Biomech*. 2020;102:109305. doi:10.1016/j.jbiomech.2019.07.049

Nature of the Thesis:
Literature reviews: 20%
MSK model development: 30%
Simulations/sensitivity studies: 30%
Documentation: 10%

Requirements:
- Motivation to work in multidisciplinary team
- Interest in movement biomechanics, and basic musculoskeletal anatomy knowledge
- Programming skills in MATLAB/Python, experience with OpenSim an advantage

Supervisors:
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