Non-invasive procedure for acquisition of mechanical properties of the torso

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Introduction:

Computational methods promise benefits for the design of braces to manage adolescent idiopathic scoliosis. However, computational methods for the design of scoliosis braces suffer an important challenge: they require a personalized model of the patient's torso biomechanics. The biggest difficulty in building a personalized model of the torso is defining its mechanical parametrization. In this work, we present a non-invasive procedure to obtain simultaneously force and deformation that characterize the mechanical response of the torso. We have tested the method on ten scoliotic patients, and we demonstrate its sensitivity by quantifying the range of forces and Cobb angles during the procedure.

Methods:

Ten patients visited the hospital for their regular scoliosis checkup. A series of low-dose radiographs was captured for each of them with the Delft DI D2RS system with fluoroscopic exposure [1]. At the time of the radiographs, a force was applied on the ribs of the patient, starting from zero and gradually increasing until a limit comfort value. The force was applied through a Sauter FH500 force sensor, and the force readings were registered with the radiographs. The patient's pelvis was fixed in place, and the shoulder was in contact with a rigid wall, as figure 1 depicts. Using force equilibrium conditions and body measurements of the patient, we can estimate the forces applied on the pelvis and the shoulder. For this study, we obtained oral and written consent according to national guidelines and the Helsinki Declaration, and with approval of the local ethics committee study (No H-17034237).

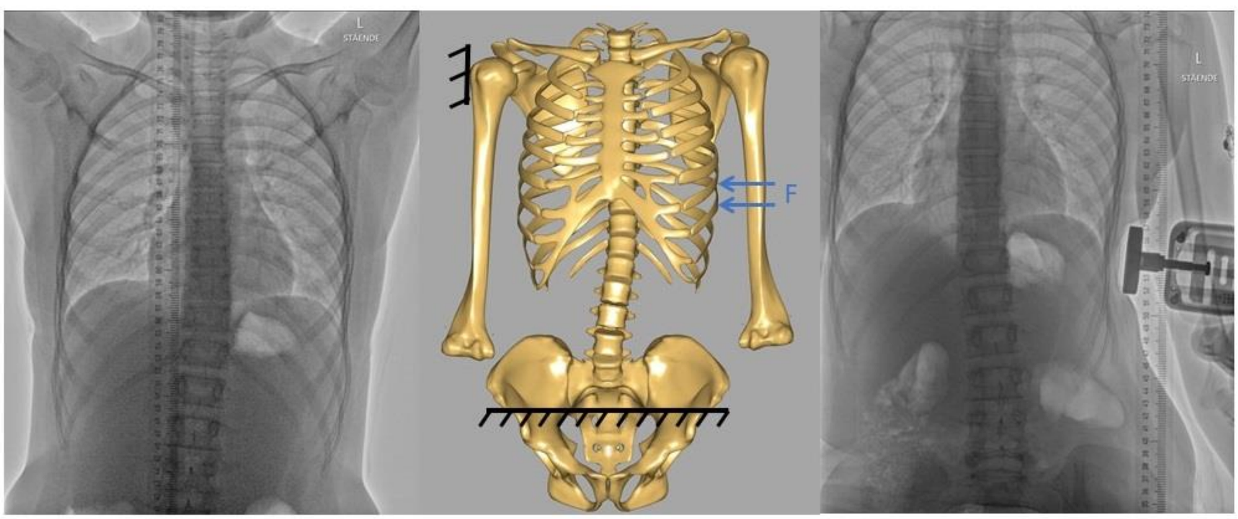

Fig 1: Left: a frontal radiograph of the patient without any applied force. Middle: a schematic of the data acquisition set up. Right: the same patient with an applied force of 68.8 N.

Results:

We have measured the applied force on the patients' ribs, as well as the change produced to their Cobb angle. The average applied force was 79 N (standard deviation 27 N), while the average change of Cobb angle was 15 degrees (standard deviation 6 degrees). The results demonstrate that the measured deformations are representative of the deformations produced by scoliosis braces. Hence, they can be used for the estimation of suitable biomechanics models. Note that the three points of contact (ribs, pelvis and shoulder) are also representative of the contacts exerted by Boston-type braces [2].

Discussion:

We have developed a procedure for the acquisition of force and deformation measurements on the torso, which enable the characterization of the mechanical response of the torso of scoliosis patients. Together with geometric registration of the captured radiographs [3], the force-deformation data can be used for mechanical parameter estimation using optimization-based algorithms [4]. The resulting personalized biomechanics models provide a crucial component for computational design of scoliosis braces.

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References:

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