GEOMETRIC AND BIOMECHANICAL POSTURAL CHARACTERISATION OF THE HUMAN TRUNK

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Introduction

Postural and biomechanical analysis of the spine and trunk require an accurate quantification of spine location with regard to the gravity line. Several studies [1, 2] used force plate system in order to estimate the center of gravity projection but very few addressed the location of the gravity line related to the spine configuration. Duval Beaupere & Al. [3] has assessed the center of gravity using a barycentric study and used X-rays for indirect estimation of this center location with regard to the spine in upright position. The position of center of weight supported by each vertebra could be placed on these X-rays. However, these studies need two different investigations and the data obtained are interpreted together with few approximations.

On the other hand, recent advances in spine and trunk geometric modelling yield an accurate 3D description of spine and pelvis with a good accuracy using stereoradiography [4].

The aim of this study is to define an analysis protocol for the location of each vertebra and the pelvis with regard to the gravity line in one measurement in order to get all information simultaneously.

Material and methods

The subject is X-rayed using a specific stereoradiographic calibration setup [4] (Figure 1) in order to get a 3D reconstruction of the spine. The calibration setup is also instrumented by a ZEBRIS force platform constituted by a 32x47 compression sensors matrix (1cm², resolution 1N), with identification of the platform co-ordinate system in the stereoradiographic setup referential. The position of the origin of the force platform is defined with direct measurement of its dimensions of the stereoradiographic setup.

Besides, two Nylon threads, each with 60 radio-opaque lead markers, are fixed on the trunk to get reference points for the trunk shape reconstruction (Figure 2). The X-ray films are scanned using a VIDAR scanner. The 3D reconstruction of spine and pelvis is performed using Non Stereo Corresponding Point technique [5]. This technique uses projection of anatomic points on the calibrated X-rays to detect their 3D location. Both stereoradiographic corresponding and non-corresponding anatomic points are used (14 anatomic points for vertebrae and 63 for pelvis). 3D trunk reconstruction is obtained with the radio-opaque markers using a similar technique: these points are considered as stereoradiographic corresponding points for trunk shape 3D reconstruction.
Then, the force platform sensor data are processed to locate the gravity line in the calibration co-ordinate system thus yielding gravity line location with regard to the spine and pelvis. The accuracy of the gravity line location was estimated to +/- 0.5 mm considering the size of sensors.

**Preliminary Results**

The protocol was efficient to get the spine configuration with regard to the gravity line. The distances between the gravity line and each centres of S1, L3-L4 disk and bicoxofemoral line were estimated for one volunteer and for one scoliotic patient (table1). The differences between healthy and scoliotic subject were found superior to the significant margin. The 3D reconstruction of the volunteer was completely obtained (Figure 3 and 4).

<table>
<thead>
<tr>
<th>Element</th>
<th>Volunteer</th>
<th>Scoliotic patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>L3-L4</td>
<td>11 mm</td>
<td>38 mm</td>
</tr>
<tr>
<td>S1</td>
<td>4 mm</td>
<td>20 mm</td>
</tr>
<tr>
<td>bicoxofemoral</td>
<td>15 mm</td>
<td>8 mm</td>
</tr>
</tbody>
</table>

Table 1: Distance between the gravity line and each element

**Discussion – conclusion**

The proposed protocol allowed to get an accurate 3D representation of the spine and the pelvis together with external trunk shape and gravity line. The distances between elements and gravity line obtained for the scoliotic patient can be an indicator of the patient’s unbalance and be helpful for better description of scoliotic configuration.

**References**