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Surface topographic evaluation of 3D vertebral body position while standing: presentation of normative reference data

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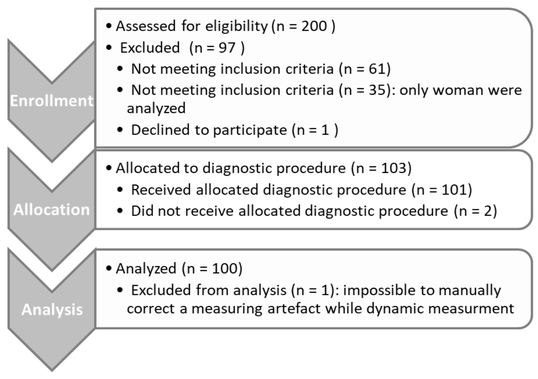
Background and Aim

Using surface topography (ST), it is possible to estimate individual vertebral body positions in an upright standing position with high precision. The technique is reliable and currently used in particular for monitoring the intra-individual progress of scoliotic patients. For the evaluation of an one-time posture analysis, a reference data set of a subject group defined as "healthy" is important. Up to now in scientific literature this is only available for global spinal parameters, like thoracic kyphosis and lumbar lordosis. Detailed 3D data for individual spinal segments are missing so far. Our study was set up to close the gap and gain these for the thoracic and lumbar vertebral bodies in females.

Method

The present evaluation is based on data from a comprehensive postural and movement analysis of asymptomatic participants with the DIERS Formetric III 4D™ system (DICAM v3.7.1.7; DIERS International GmbH, Schlangenbad, Germany), a light-optical scanning system based on ST. The three-dimensional camera unit records a defined position with a frequency of 60 Hz. The spatial, individual three-dimensional position is calculated for each thoracic and lumbar vertebra and the pelvis. This study was registered with WHO (INT: DRKS00010834) and approved by the responsible ethics committee at the Rhineland–Palatinate Medical Association (837.194.16). In order to analyze a cohort that is as „healthy“ as possible, strong inclusion/exclusion criteria were defined. 100 women, aged 20–64 years, in habitual standing positions have been analyzed. Two-sample t-tests were used for age comparisons. To test deviations from symmetrical zero positions of VP–L4, one-sample t-tests were used.

Figure 1: Transparent reporting of trial adopted from CONSORT



Results

Participants: The mean ± standard deviation (SD) age of the entire group (EG) was 39.8 ± 12.1 (20–64) years with a BMI of 23.0 ± 2.9 kg/m². The mean age and BMI of the younger group were 28.9 ± 5.0 (20–40) and 22.3 ± 2.7 kg/m², and the older group was 50.7 ± 5.3 (42–64), 23.7 ± 3.0 kg/m².

Coronal plane: on average, the vertebral bodies were tilted to the right between the VP and T4 (maximum: T2 -1.8 ± 3.2), while between T6 and T11 they were tilted to the left (maximum: T7 1.1 ± 1.9). T5 and L2 were in a neutral position, overall we see a mean right-sided lateral flexion from T2 to T7 (apex at T5) (see Figure 2). **Sagittal plane**: the kyphotic apex located at T8 with - 0.5 ± 3.6 and the lumbar lordotic apex at L3 with -2.1 ± 7.4 (see Figure 3). **Transverse plane**: participants had a mean vertebral body rotation to the right ranging from T6 to L4 (maximum: T11 - 2.2 ± 3.5) (see Figure 4). Age-specific differences were seen in the sagittal plane and had little effect on overall posture.

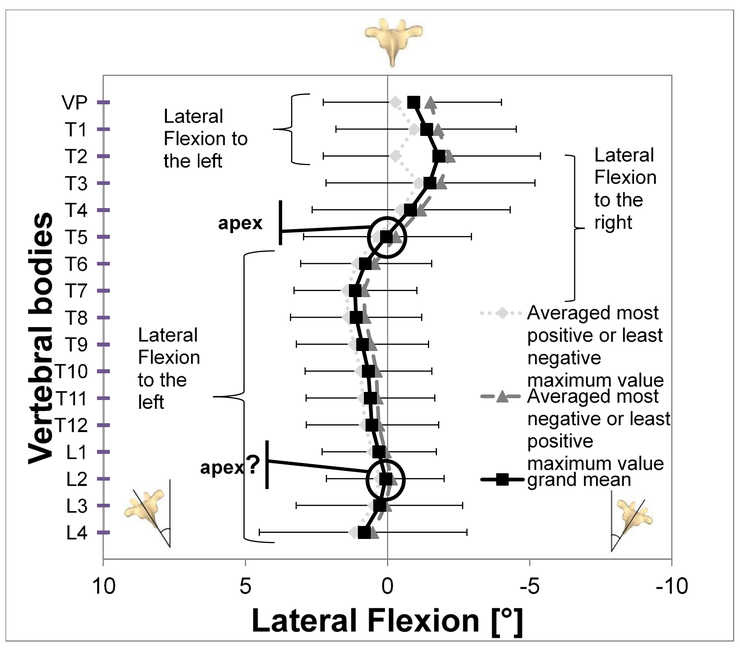


Figure 2: Vertebral body positions in the coronal plane. Positive values indicate tilt to the left, negative values to the right. Averaged most positive or least negative maximum value, most negative or least positive with one-sided SDs, and grand means of EG are displayed; apex, area, and direction of lateral flexion are marked (1).

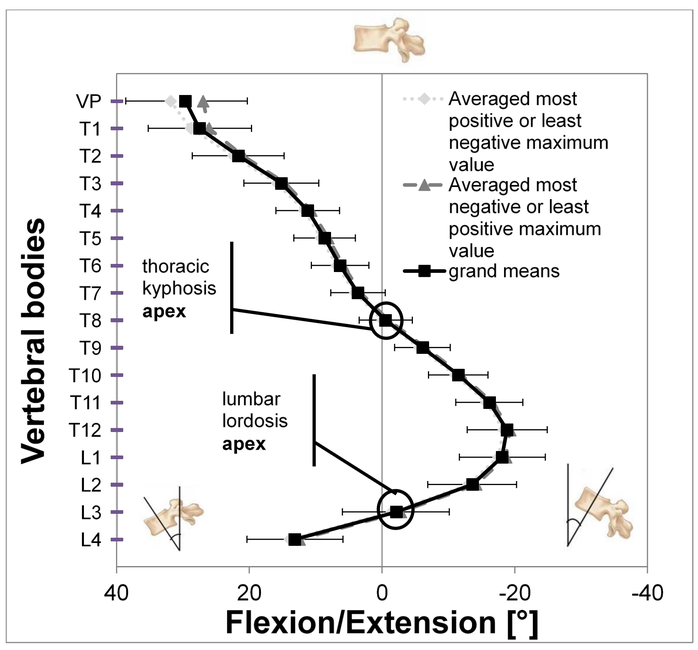


Figure 3: Vertebral body positions in the sagittal plane. Positive values indicate tilt toward flexion, negative values toward extension. Averaged most positive or least negative maximum value, most negative or least positive with one-sided SDs, and grand means of EG are displayed; thoracic kyphosis and lumbar lordosis apex are marked (1).

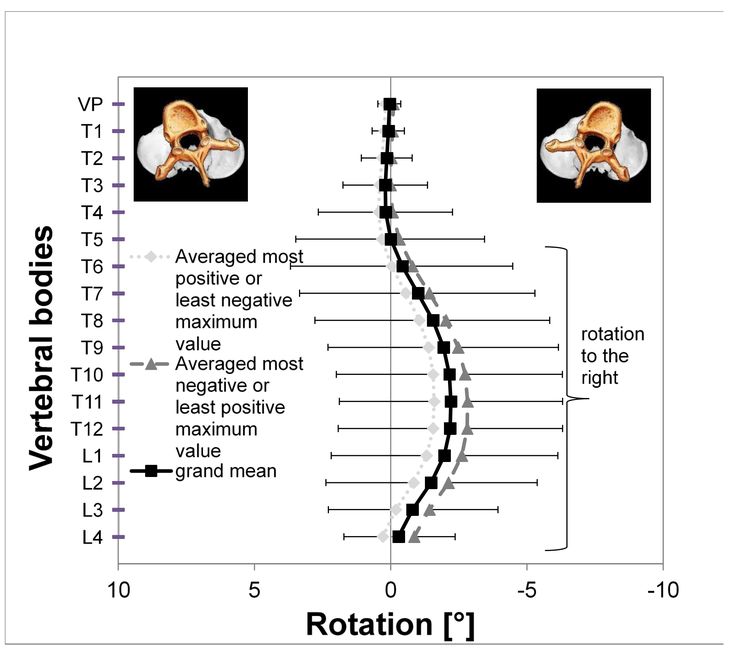


Figure 4: Vertebral body positions in transversal plane. Positive values mean indicate rotation to the left, negative values to the right. Averaged most positive or least negative maximum value, most negative or least positive with one-sided SDs, and grand means of EG are displayed; area and direction of rotation are marked (1).

Discussion and Conclusions

In habitual standing of healthy women, in the coronal and transverse planes we expected the vertebral bodies in an average spine posture to be in symmetrical zero positions. Unexpected we found systematically tilted vertebral bodies in all three planes. In addition to well-known inclination in the sagittal plane, we determined a systematic vertebral rotation and lateral flexion to the right in vertebral segments T2–T7. Only little age-specific differences have be seen. These results should be taken into account in the rating of postural analysis and could influence the definition of therapy goals in the future. Low measurement values of approximately 1° should be interpreted with caution considering a measuring error of 3°for surface rotation when compared to radiography (2). To our knowledge, this is the first study to describe the specific vertebral body positions using ST measurements. Therefore, the interpretation of the data may be challenging in some circumstances, such as the lateral flexion, the exact description of the apex, and inflection points of the spinal curvatures. The data presented are published in (1). Data analysis for additional subjects is currently running, so that the results can be extended for male participants and the differences to females.

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References

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[2]Drerup B, Hierholzer E. (1994) Back shape measurement using video rasterstereography and three-dimensional reconstruction of spinal shape. Clin Biomech (Bristol, Avon). DOI: 10.1016/0268−0033(94)90055−8