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Basic Science

What does the shape of our back tell us? Correlation between sacrum orientation and lumbar lordosis

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Abstract

BACKGROUND CONTEXT: Sacral slope and lumbar lordosis (LL) have been studied extensively in recent years via x-ray examinations and strongly correlate with each other. This raises, first, the question of the reproducibility of this correlation in multiple standing phases and, second, if this correlation can be achieved using non-radiological measurement tools.

PURPOSE: This study aimed (1) to determine the extent to which the back-shape measurements correspond to the correlations between the sacral slope and LL found in previous radiological investigations, (2) to identify a possible effect of age and gender on this correlation, and (3) to evaluate the extent to which this correlation is affected by repeated standing phases.

STUDY DESIGN/SAMPLE: This is an observational cohort study.

PATIENT SAMPLE: A total of 410 asymptomatic subjects (non-athletes), 21 asymptomatic soccer players (athletes), and 176 patients with low back pain (LBP) were included.

OUTCOME MEASURES: The correlation between sacrum orientation (SO) and LL was determined in six repetitive upright standing postures.

MATERIALS AND METHODS: A non-invasive strain-gauge based measuring system was used.

RESULTS: Back-shape measurements yielded a similar correlation to that measured in previous x-ray examinations. The coefficient of determination (R^2) between SO and LL ranged between 0.76 and 0.79 for the asymptomatic cohort. Athletes showed the strongest correlation ($0.76 \le R^2 \le 0.84$). For patients with LBP, the correlation substantially decreased ($0.18 \le R^2 \le 0.39$). R^2 was not strongly affected by repeated standing phases.

CONCLUSIONS: The correlation between SO and LL can be assessed by surface measurements of the back shape and is not influenced by natural variations in the standing posture.

Keywords: Human posture; Lumbar lordosis; Non-invasive; Sacrum orientation; Standing

FDA device/drug status: Not applicable.

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Introduction

The clinical importance of the sagittal spinal alignment was increasingly recognized for various spinal diseases in recent years [1,2]. The spinal morphology, however, varies from one individual to another and is specific for each person. A central part is played by the pelvis' morphology provided by x-rays because of the close correlation between the anatomical parameter of the pelvis and the spinal curvature [3–6]. Legaye et al. [6] and Vialle et al. [5] reported a Pearson correlation coefficient of R=0.86 between the sacral slope and the maximum lumbar lordosis (LL) in asymptomatic subjects using x-ray.

As frequent diagnostic x-ray examinations are, however, ethically questionable, new technological tools to estimate the sacral slope and LL non-invasively and without radiation are currently increasingly employed [7–13]. These devices, however, measure the back surface and not the spinal shape itself, and therefore only allow an estimation of the sacrum orientation (SO) and LL. Consequently, the first aim of the current study was to determine the extent to which the back-shape measurements correspond with the correlations between the sacral slope and LL found in previous radiological investigations. We hypothesized that the correlation measured via back-shape measurements is in good agreement with earlier x-ray measurements by Legaye et al. [6] and Vialle et al. [5]

The second aim was to identify a possible effect of age and gender on the correlation between the SO and LL within different cohorts: asymptomatic non-athletes, athletes, and patients with low back pain (LBP). In accordance to own previous investigations [14,15], we expected that gender substantially affects this correlation. We further postulated that the correlation differs significantly between the investigated cohorts because of training- and pain-related functional adaptations, respectively.

Physiological upright standing is highly individual and, as such, standing can be reached in different ways for each person with a unique pattern of spinopelvic balance and sagittal alignment [16,17]. Moreover, standing is highly irreproducible, not predictable, and therefore does not reflect an individual specific behavioral pattern [18–20]. In combination, this raises the question of how does the variability in different standing postures influence the correlation between the SO and LL. Therefore, the third aim of our study was to evaluate the extent to which this correlation is affected by repeated upright standing phases. Despite the known irreproducibility of standing, we postulated that repeated standing phases do not affect the correlation between the SO and LL.

Materials and methods

Ethical review committee statement

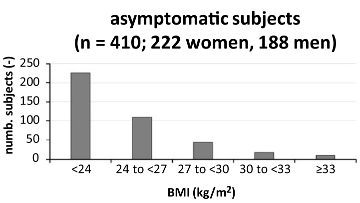
The present study was approved by the local Research Ethics Committee of our hospitals (internal registry numbers: EA4/011/10, EA1/162/13, 4385-2012, 4427-12, and 5233-15). The study participants signed a written consent before the measurements.

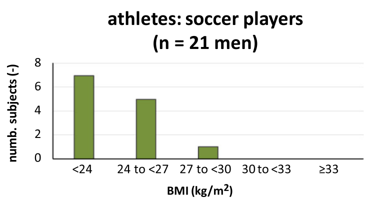
Study cohort

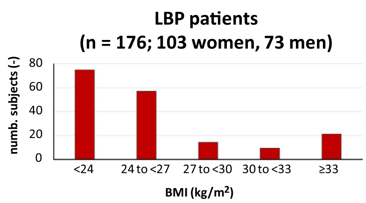
The group of asymptomatic subjects included 410 participants (222 women and 188 men); the group of athletes includes 21 male soccer players of a professional team with seven 90-minute training sessions per week (10.5 h/wk). Both groups (non-athletes and athletes) never required spinal or pelvic surgery and were free of pain in the lower back or pelvis for the last 6 months. More details are provided in the Table. The last group, the patients with LBP, included 176 patients (103 women and 73 men) with chronic LBP longer than 12

Table
Data for asymptomatic subjects (non-athletes and soccer players) and patients with LBP

Study groups	Number of women and men	Age (y)	Body height (cm)	Body weight (kg)	BMI (kg/m^2)
Asymptomatic subjects (non-athletes)	Women: 222	41 (20–75)	168 (148–184)	65 (45–105)	23.4 (16.7–35.0)
	Men: 188	40 (20–74)	180 (159–206)	80 (55–120)	24.8 (17.9–35.8)
Soccer players	Men: 21	23 (19–28)	181 (163–193)	79 (63.3–111)	23.8 (21.4–26.5)
Patients with LBP	Women: 103	57 (24–84)	167 (152–189)	75 (52–120)	26.5 (19.8–44.1)
	Men: 73	54.5 (25–80)	181.5 (164–199)	93 (74–150)	30.0 (21.2–42.4)







LBP, low back pain; BMI, body mass index.
Median and ranges are given for age, body height, body weight, and BMI. Diagrams show the number of subjects in different clusters of BMI.