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Case Series

Is There a Gender-Specific Full Body Sagittal Profile for Different Spinopelvic Relationships? A Study on Propensity-Matched Cohorts

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Abstract

Design: Retrospective review.
Objective: To evaluate gender-related differences in compensatory recruitment to progressive sagittal malalignment.
Summary of Background Data: Recent research has elucidated compensatory mechanisms recruited in response to sagittal malalignment, but gender-specific differences in compensatory recruitment patterns is unknown.
Methods: Single-center study of patients with full body x-rays. A female group was propensity matched by age, body mass index (BMI), and pelvic incidence (PI) to a male group. Patients were then stratified into five groups of progressive PI−lumbar lordosis (LL) mismatch ($<0°$, $0°-10°$, $10°-20°$, $20°-30°$, $>30°$). Differences between PI-LL groups were assessed with analysis of variance, and between genders by unpaired *t* test. Knee flexion to pelvic tilt (PT) ratio was computed and compared between genders. Multivariate regression to develop predictive models for PT was performed for each gender, first with spinopelvic parameters and subsequently with inclusion of lower limb parameters.
Results: A total of 942 patient visits were included: 471 females (mean age 54 years, BMI 27, PI 51°) and 471 males (mean age 52 years, BMI 27, PI 51°). At the lowest level of malalignment, females had greater PT and less knee flexion. With progressive malalignment, females continued to exhibit a pattern of greater pelvic retroversion and less knee flexion compared to males. Hip extension was higher in females with progressive PI-LL mismatch groups. Both genders progressively recruited knee flexion and pelvic retroversion with increased PI-LL mismatch, except that at the higher PI-LL mismatch groups, only males continued to recruit knee flexion (all $p < .05$). Inclusion of lower limbs in the regression for PT markedly improved correlation coefficients for females but not for males.
Conclusions: With progressive sagittal malalignment, men recruit more knee flexion and women recruit more pelvic tilt and hip extension. Knee flexion is a possible mechanism to gain pelvic tilt for females whereas for males, knee flexion is an independent compensatory mechanism.

Keywords: Compensatory recruitment; Adult spinal deformity; PI-LL mismatch; Full body x-ray; Sagittal malalignment

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This IRB approved study is a single-center retrospective review of full body radiographs of patients presenting to an academic spine practice with a diverse range of clinical presentations.

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Introduction

Gender has long been recognized as an important factor in the etiology of spinal pathologies. Gender differences in spinal alignment manifest as early as the prepubescent period [1,2] and contribute to the pathophysiology of such diverse conditions as adolescent idiopathic scoliosis and Scheuermann kyphosis [3,4]. However, the extent to which these gender differences contribute to differences in the body's compensatory response to spinal pathology later in life such as in adult spinal deformity (ASD) has not been as extensively studied.

Sagittal alignment plays a critical role in disability and functional outcomes [5,6] for ASD patients. Previous studies have identified several compensatory mechanisms ASD patients recruit to pull back the center of mass and the head over the pelvis and maintain upright posture when faced with spinal sagittal malalignment [7-12]. A loss of lumbar lordosis (LL) is thought to be the primary derangement that triggers a pathophysiological cascade of sagittal plane deformity. This can be quantified by the mismatch between pelvic incidence (PI) and LL, or PI-LL spinopelvic mismatch [13], and its importance is highlighted by its inclusion as a sagittal modifier in the SRS-Schwab classification for ASD [6,14]. An acceptable mismatch was defined as PI-LL $< \pm 10$.

There has been increasing appreciation of the entire musculoskeletal system's participation in compensating for progressive sagittal malalignment in ASD patients with spinopelvic mismatch [7,10]. Objectively evaluating these interactions requires global radiographic evaluation of patients from the head to the feet. The EOS imaging system has been recently introduced into the medical field and provides such a head-to-toe evaluation, providing a full image of a patient's spinal deformity and revealing any compensatory mechanisms being recruited by the patient [15-17].

Using this novel imaging technology, knee flexion, along with ankle flexion, pelvic retroversion, and hip extension have been identified as additional compensatory mechanisms that are recruited in ASD patients [10]. Previously, it was demonstrated that spinopelvic mismatch triggers a chain of compensatory mechanisms to counteract global malalignment [18-20]. The impact of age on compensatory mechanism recruitment demonstrated more pelvic and lower limb involvement for older patients and less thoracic spine adaptation, further demonstrating the importance of demographic characteristics on compensatory recruitment [18]. However, in order to individualize diagnosis and treatment for these complex patients, further study of how compensation differs among individuals is warranted.

Prior studies comparing sagittal alignment based on demographic characteristics such as gender have been limited to asymptomatic subjects [21,22]. However, there is a lack of full body analysis of gender differences in the symptomatic population of patients presenting with a variety of spinal complaints either due to or independent of spinopelvic mismatch. This study investigates whether the chain of compensation in response to progressive sagittal malalignment is gender dependent when controlling for other confounding factors such as age, body mass index (BMI) and pelvic morphology, and is the first to specifically evaluate differences in compensatory recruitment by gender using full body imaging.

Methods

Inclusion criteria and data acquisition

This single-center study retrospectively reviewed full body radiographs of patients presenting to an academic spine practice with a diverse range of clinical presentations.

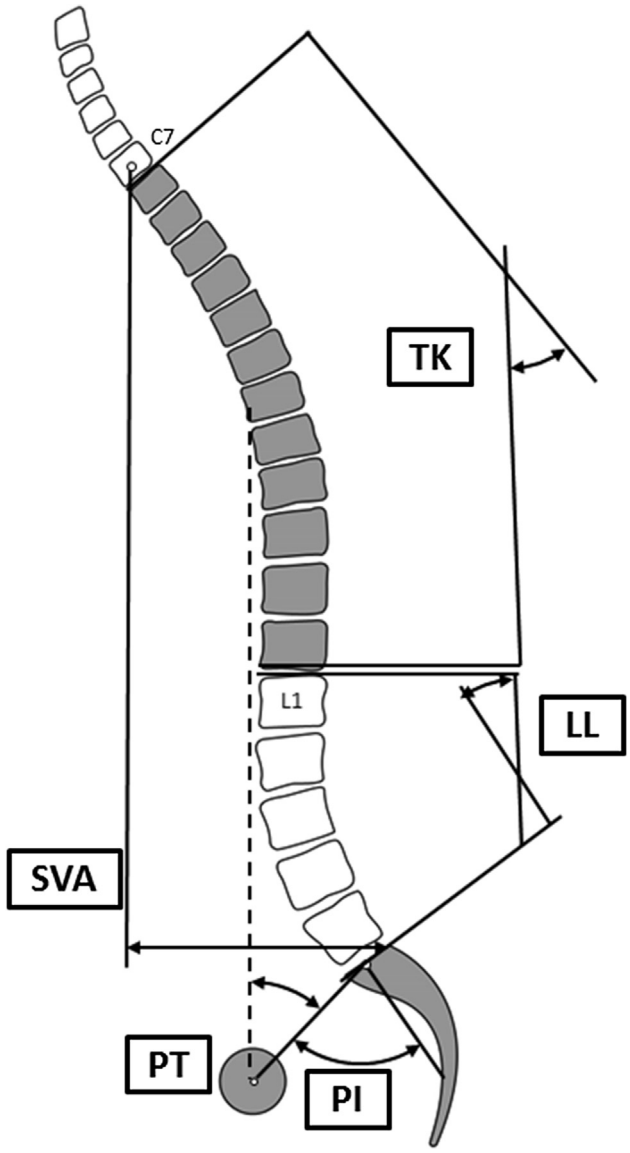

Fig. 1. Spino-pelvic sagittal radiographic parameters.