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RESEARCH ARTICLE

THE IMPACT OF BODY MASS INDEX ON THE SPINOPELVIC PARAMETERS IN ASYMPTOMATIC YOUNG ADULTS

[1,*]Utku Adilay, [2]Deniz Gulabi, [3]BulentGuclu, [2]Mehm*et al*i Uysal, [4]Ahmet Akca, [2]İlker Colak and [2]Gultekin Sıtkı Cecen

[1]Neurosugery Department, Balikesir University School of Medicine, Balikesir, Turkey
[2]Orthopaedic and Traumatology Clinic, Kartal Dr. Lutfi Kirdar Training and Research Hospital Istanbul, Turkey
[3]Neurosurgery Clinic, Kartal Dr. Lutfi Kirdar Training and Research Hospital, Istanbul, Turkey
[4]Radiology Clinic, Kartal Dr. Lutfi Kirdar Training and Research Hospital, Istanbul, Turkey

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ABSTRACT

Objective: Obesity is recognized as a major public health problem and is associated with various musculoskeletal disorders including impairment of the spine. The initial aim of this work was to investigate the correlations between body mass index (BMI) and spinopelvic parameters (pelvic tilt, sacral slope, and pelvic incidence) in a large population of healthy young adults.
Materials and Methods: This study analysed a total of 156(105 male and 51 female), healthy adult adults. For each subject, a record was made of age, gender and BMI (weight in kilograms divided by the square of height in meters). Standing lateral radiographs of the lumbosacral region were taken to obtain the spinopelvic parameters of pelvictilt, sacralslope, and pelvic incidence. The correlations between BMI and spinopelvic parameters were analysed.
Results: The intra observer concordance was calculated for each measured parameter and was found to be excellent, giving an intra class correlation coefficient of 0.97. The mean age of the patients was 26.8 ± 5.2 years. The mean BMI was25.80 ± 4.02 kg/m2. Sixty three (40.4 %) patients were normal weight, 72 (46.2%) patients were overweight, and21(13.4 %) patients were obese (BMI >30). A statistically significant difference was found between the pelvictilt, pelvicincidence and sacralslope measurements and BMI measurements (p<0.01).
Conclusion: Obesity is associated with a statistically significant increase in the spinopelvic parameters that reach statistically significant difference. Preventing obesity may also prevent the degenerative problems associated with excessive loading on the lumbosacral junction.

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INTRODUCTION

Obesity is one of the major public health problems and is associated with various musculoskeletal disorders, especially impairment of the spine (Fanuele *et al.,* 2002; Grover *et al.*, 2016). The sagittal plane alignment of the spine and the pelvis comprises a set of segments linked together to maintain a stable posture with a minimum of energy expenditure (Roussouly *et al.,* 2011). The three spinopelvic parameters of pelvic tilt (PT), sacral slope (SS), and pelvic incidence (PI) were introduced by (Legaye *et al.,* 1998) to define the shape and orientation of the spine and the pelvis. PI is a fixed parameter and PT and sacral slope are two positional parameters (Berthonnaud *et al.,* 1998). Recent studies have confirmed the correlations between two positional parameters, and the single fixed morphological parameter of pelvic incidence (Hanson *et al.,* 2002). To date, a few studies have been conducted to evaluate the effect of body mass index (BMI) on spino-pelvic orientation (Vargas *et al.,* 2013). The initial aim of this work was to confirm the correlations between BMI and spino-pelvic parameters in a large population of asymptomatic young adults.

Corresponding author: **Utku Adilay,**
Neurosugery Department, Balikesir University School of Medicine, Balikesir, Turkey.

MATERIAL AND METHODS

In this study, an analysis was made of a total of 156 (105 male and 51 female), healthy adults. Subjects included in the study were between 18 and 30 years old, had no history of surgery for hip, pelvis or spine disorders, had no back pain at the time of the study or had never sought medical advice for back pain, no lower extremity leg discrepancy, and no spinal, lower extremity or pelvic deformities. The study was conducted at the Orthopedics and Traumatology Clinic, Ministry of Health, Dr Lutfu Kirdar Kartal Research and Training Hospital, Kartal/Istanbul, Turkey and Neurosurgery Clinic, Ministry of Health, Dr Lutfu Kirdar Kartal Research and Training Hospital, Kartal/Istanbul, Turkey. Informed consent was obtained from all participants. All procedures performed in this study were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki declaration and its later amendments. Formal consent of the patients were taken. For each subject, a record was made of age, gender and BMI (weight in kilograms divided by the square of height in meters). Standing lateral radiographs of the lumbosacral region were taken to obtain the pelvic parameters

Radiological assessment

Whole lumbosacral lateral radiographs in a standing position were taken with standard 43x43 cm lumbosacral spire X-ray. The adults were instructed to stand straight and relaxed, with their knees fully extended. The elbows were flexed, with both hands resting on a horizontal bar at the level of their shoulders. Both femoral heads were visualızed on the X-ray The film-to-focus distance was 1.8 m. Three the spinopelvic parameters were evaluated. The pelvic tilt (PT) is defined as the angle between a vertical line originating at the hip axis and a line drawn between the same point and middle of the superior endplate of S1.

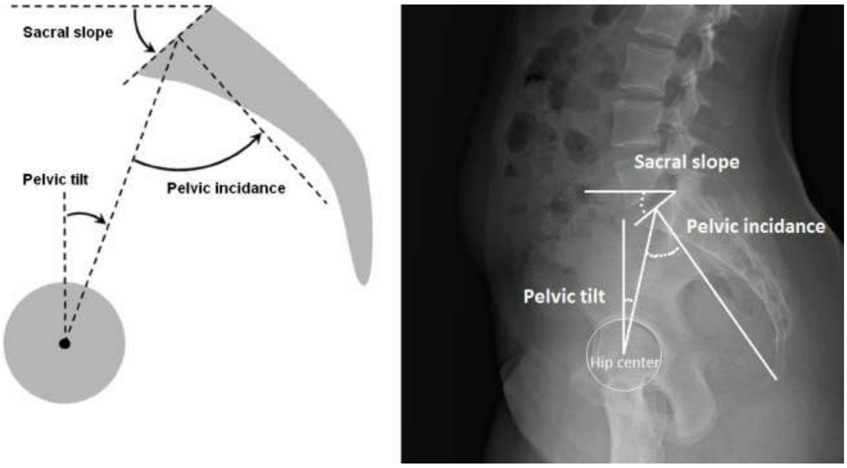

Figure 1. Left: Drawing showing all spinopelvic parameters. Right: All spinopelvic parameters were shown on a lateral radiograph

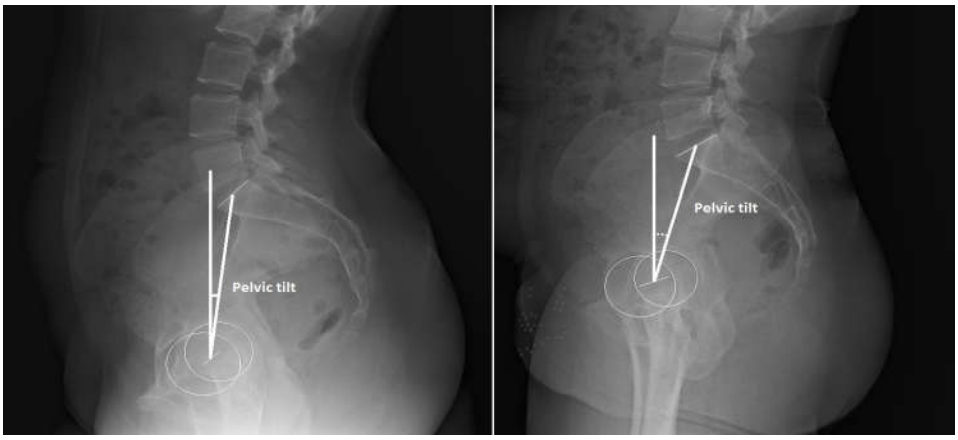

Figure 2. Left: Pelvic tilt of normal weight young adult. Right: Pelvic tilt of obese young adult

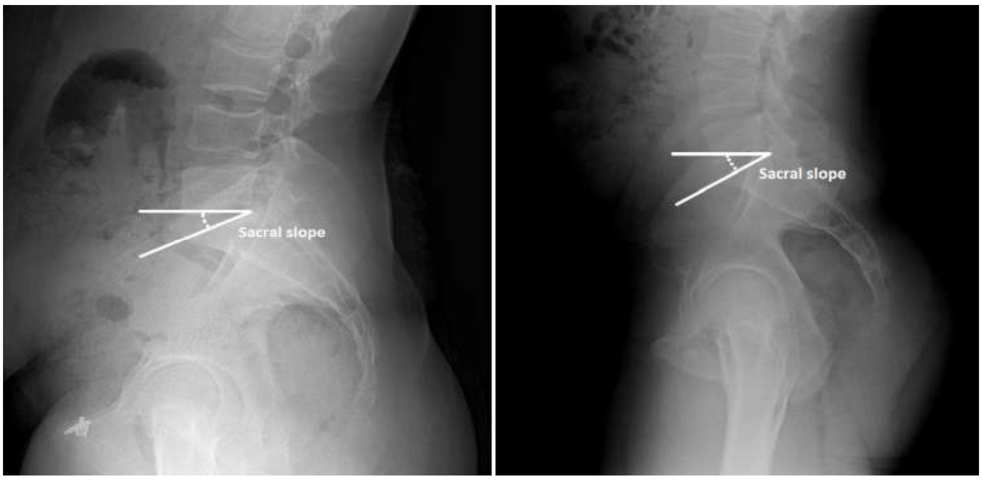

Figure 3. Left: Sacral slope of normal weight young adult. Right: Sacral slope of obese young adult

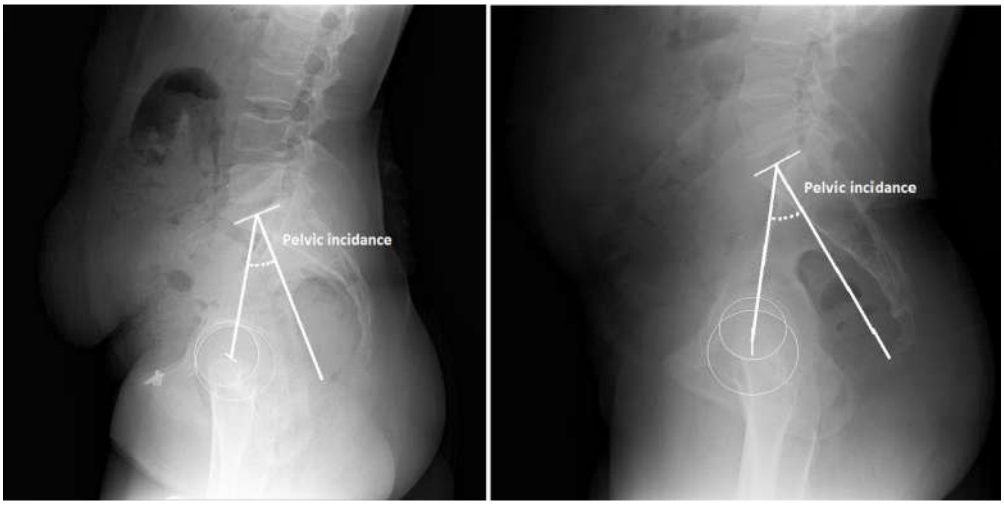

Figure 4. Left: Pelvic incidence of normal weight young adult. Right: Pelvic incidence of obese young adult

The sacral slope (SS) is defined as the angle between the horizontal line and the sacral plateau. Pelvic incidence (PI) is defined as the angle between the line perpendicular to the sacral plateau at its midpoint and a line connecting the same point to the hip axis (the center of the bicoxo- femoral axis) (Fig. 1). All radiographs were reviewed with the strongest criteria for adequacy. Radiographs that revealed obliqueness in any plane were repeated until obtaining suitable radiograph. All images were digitized and transferred to the picture archiving and communication system (PACS, GE Healthcare, Chicago, IL, USA) for measurement.

The independent observer who was blinded to the study design measured all radiographic measurements twice at an interval of 1 week. All measured values were calculated to two decimal places. To eliminate inter observer variability, a single radiographic reviewer was used.

Statistical Analysis

For the evaluation of findings obtained in the study, statistical analyses were made using IBM SPSS 22.0 software. Descriptive statistical methods were used (mean± standard deviation [SD]) and in the comparison of quantitative data, the One Way Anova test was applied in the comparison between groups of parameters showing normal distribution. To determine from which group the difference originated, the Tukey HSD test was used. In the comparison between two groups of parameters not showing normal distribution, the Student's t-test was applied. A value of p<0.05 was accepted as statistically significant.

RESULTS

The intra observer concordance was calculated for each measured parameter and was found to be excellent, giving an intra class correlation coefficient of 0.97 (0.89–1.00), thereby demonstrating intra observer reliability. The mean age of the patients was 26.8± 5.2years (range 18 - 30). The mean BMI was 25.80±4.02kg/m2 (range 17.26 – 35.56 kg/m2). Sixty three (40.4%) patients were normal weight (BMI 17.26–24.9 kg/ m2), 72 (46.2 %)patients were overweight (BMI 25–29.9 kg/m2), and 21 (13.4 %) patients were obese (BMI >30) (Table 1). The mean PT measurement for all young adults was 15.27°±7.97.

Table 1. Distribution of General Characteristics

BMI	Min-Max	17.26 – 35.56
	Mean±SD	25.80±4.02
	Normal (n;%)	63 (40.4%)
	overweight (n;%)	72 (46.2%)
	Obese (n;%)	21 (13.4%)
Pelvic Tilt	Min-Max	1.74° – 33.90°
	Mean±SD	15.27°±7.97
Sacral Slope	Min-Max	19.56° – 52.68°
	Mean±SD	31.31°±8.68
Pelvic Incidence	Min-Max	34.34° – 86.22°
	Mean±SD	46.58°±11.73
Gender	Female (n;%)	51 (32.7%)
	Male (n;%)	105(67.3%)

It was 13.33°±7.24 for normal weight young adults, 15.79°±8.22 for overweight young adults, 19.32°±7.31 for obese young adults (Fig. 2). A statistically significant difference was found between the pelvic tilt measurements according to the BMI classification (p<0.01). As a result of the paired comparisons applied to determine from which classification the difference originated, the mean pelvic tilt of the obese group was determined to be statistically signifcantly higher than the mean pelvic tilt of the normal weight group (p<0.01). No signficant difference was determined in the mean pelvic tilt values between the other groups (Table 2).

Table 2. Evaluations according to BMI and Abdominal Circumference

		Pelvic Tilt	Sacral Slope	Pelvic Incidence
BMI	Normal	13.33°±7.24	25.78°±6.1	39.11°±12.45
	Overweight	15.79°±8.22	32.34°±6.6	48.23°±10.19
	Obese	19.32°±7.31	44.34°±5.3	63.67°±11.20
	^{1}p	**p<0.01 (normal-obese)	**p<0.01 (for all groups)	**p<0.01 (normal-obese) *p<0.05 (overweight-obese)

Oneway ANOVA Test**p<0.01, *p<0.05

The mean SS measurement for all young adults was 31.31°±8.68. It was 25.78°±6.1 for normal weight young adults, 32.34°±6.6 for overweight young adults, 44.34°±5.3 for obese young adults (Fig. 3). A statistically significant difference was found between the sacral slope measurements according to the BMI classification (p<0.01). As a result of the paired comparisons applied to determine from which classification the difference originated, the mean sacral slope of the obese group was determined to be statistically significantly higher than the mean sacral slope of the normal weight group (p<0.01) and of the overweight group (p<0.01). The mean sacral slope value of the overweight group was determined to be statistically signficantly higher than that of the normal weight group (p<0.01). The mean PI measurement for all young adults was 46.58°±11.73. It was 39.11°±12.45 for normal weight young adults, 48.23°±10.19 for overweight young adults, 63.67°±11.20 for obese young adults (Fig. 4). A statistically significant difference was found between the pelvic incidence measurements according to the BMI classification (p<0.01). As a result of the paired comparisons applied to determine from which classification the difference originated, the mean pelvic incidence of the obese group was determined to be statistically signifcantly higher than the mean pelvic incidence of the normal weight group (p<0.01) and of the overweight group (p<0.05). No significant difference was determined between the overweight and the normal weight groups in respect of the pelvic incidence measurements (p>0.05). For PT, SS and PI, there were no statistically difference between male and female young adults.

DISCUSSION

It is well known that as BMI increases, the degenerative process in the lumbar vertebrae will also increase dramatically. The most important findings of the present study were that BMI affects the spinopelvic parameters and there was a positive correlation between these parameters and BMI. As BMI increases, so the spinopelvic parameters also increase. The subjects in the present study were in a young age group and healthy, with no back pain or any musculoskeletal system disorders. So as the subjects in our study were young adults, the effect of aging on spinopelvic parameters did not confuse our rersults. Having enrolled a cohort of 156 asymptomatic young adults, this study yielded a physiological norm for several spinopelvic parameters that represent pelvic balance. (Guigui *et al*., 2003) measured average values for pelvic tilt in healthy young individuals: 13.7° in females and 12.7° in males. The mean value of pelvic tilt in normal weight adults in our study was 13.33° ±7.24.

This finding was comparable with the result of Guigui *et al*. However the mean value of pelvic tilt in all asymptomatic adults in our study was 15.27°±7.97. This was because of high pelvic tilt values of overweight and obese asymptomatic young adults. A statistically significant difference was found between the pelvic tilt measurements between normal weight young aduls and obese young adults (p<0.01). The mean sacral slope in our study was 31.31°±8.68 for all young adults. In normal weight young adults it was 25.78°±6.1, in overweight young adults it was 32.34°±6.6, in obese young adults it was 44.34°±5.3. A statistically significant difference was found between the sacral slope measurements according to the BMI classification for all groups (p<0.01). Our study showed that there was a strong correlation between sacral slope and BMI. The mean value of PI in our study was 46.58°±11.73, ranging from 34.34° to 86.22°. This finding was comparable with the result of other studies which reported a mean PI value of 47.8° in a Korean population and 44.6˚in a Chinese population (Lee *et al.,* 2011). In a study by (Kalfopulos *et al.,*2012), the mean PI value was 51.91˚ in a Mexican population. The variation of PI in these cohort groups could be related to the ethinicty of the study group, as suggested by (Zhu *et al*., 2014). Lonner *et al*., 2010 also concluded that ethnicity may influence an individual's natural spinopelvic alignment. Knowledge of the preoperative spinopelvic parameter measurements is extremely important especially in patients to be operated on for spinal deformities. Lafage *et al.,* 2010 reported that patients with high PI had unfavourable outcomes following pedicle subtraction osteotomy for thoracic kyphosis restoration. Therefore patients with high PI valuesare much more likely to be less satisfied compared to those with low PI values.Our study showed that pelvic incidence of the obese group was determined to be statistically signifcantly higher than the mean pelvic incidence of the normal weight group (p<0.01) and of the overweight group (p<0.05). So there was a strong correlation between PI and BMI. Regarding all the results obesity and overweight are strongly correlated with high sacral slope values. Obesity is strongly correlated is with high pelvic tilt values but nor overweight. Pelvic incidence is the sum of the sacral slope and pelvic tilt so obesity is strongly correlated with high PI values however overweight is less strongly correlated with high PI values.

Relatively, little is known about the importance of spino-pelvic parameters in human musculoskeletal disorders. PI is an important anatomic parameter that describes the positional configuration of the pelvis and of the sacrum. The spine reacts to this position by adapting through lumbar lordosis, the amount of lordosis increasing as the SS increases to balance the trunk in the upright position (Vargas *et al.,* 2014). In the present study, we recommended that there is a positive correlation between the BMI and spinopelvic parameters. As BMI increases, so the PI, PT and SS values will increase. Vargas *et al*. reported a positive correlation between BMI and spinopelvic parameters and the results of the current study were in line with (Vergas *et al*., 2014). This finding implies that in obese individuals, the lumbosacral junction is subject to greater shear loads and could be at high risk of spondyolisthesis, as has been reported in previous studies (Barrey *et al.,* 2007; Hanson *et al.,* 2002; Labelle *et al.,* 2004)
This cohort study has some limitations. Firstly, the sample size was small, which compromises the statistical power for a sound conclusion. Secondly, spinal parameters such as thoracal kyphosis, lumbar lordosis and C7 plumb line were not measured due to the lack of orthoroentgograms. Future studies could be designed to include spinal measurements of larger sample sizes. However, a strong aspect of the study is that strict criteria were applied in the selection of subjects and all measurements were made by an independent assessor using software. The intraclass coefficient was 0.97 for the measurements.

Conclusion

In conclusion, obesity is associated with a statistically significant increase in the spinopelvic parameters. Preventing obesity may also prevent the degenerative problems associated with excessive loading on the lumbosacral junction.

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