ORTHOPOAEDICS

LUMBAR MORPHOTYPES ANALYSIS IN A POPULATION OF ASYMPTOMATIC YOUNG ADULTS
About 94 Subjects


ABSTRACT • Introduction: Several studies suggest the importance of lumbar lordosis (LL) and pelvic parameters (PP) in sagittal balance and their central role in the disco-vertebral disorders. This radiographic study assesses pelvic parameters by sex and classifies lumbar morphotypes in a population of asymptomatic young subjects. Materials and methods: A sample of 95 asymptomatic young adults free of spinal pathology was recruited for a cross-sectional study. There were 54 men of which one was excluded and 41 women aged between 21 and 30 years. Each participant’s pelvic incidence (PI), sacral slope (SS) pelvic tilt (PT) were measured from a lateral radiograph of the lumbar spine in a standing position. In addition, a classification using the 4 morphotypes of Roussouly was made. Results: There was no significant difference in the PI, SS or PT between men and women. The mean value was 51.34°, 39.85° and 11.11° for the PI, SS and PT respectively. In addition, 12.76% of the subjects were classified as type 1, 20.21% as type 2, 44.68% as type 3 and 22.34% as type 4. Conclusion: Analysis of this sample gives an idea of the prevalence of each morphotype among asymptomatic Lebanese young adults and the disco-vertebral pathologies that may result. More than half of the subjects are at risk of suffering from such diseases according to the study.

Keywords: pelvic parameters; sagittal balance; spinal morphotype; lumbar lordosis

INTRODUCTION

Humans are the only species that can maintain a bipedal posture completely vertical, because of a balance between the spinal parameters and those of the pelvis [1].

In fact, the spinal column is in an economic position due to its curves, in particular the lumbar lordosis [2]. Several authors have suggested the adverse effects of reduced lumbar lordosis, also known as “flat-back deformity” [3,4,5]. Recently, due to the importance of lumbar lordosis as a transition segment between the trunk and the pelvic unit/lower limbs, Roussouly classified the healthy population into four qualitative lumbar spine morphotypes according to the pelvic parameters and the magnitude of the angles of lumbar lordosis and thoracic kyphosis, which may have an impact on sagittal balance of the spine and disco-vertebral pathological repercussions [3,6] (Fig. 1).

In general, types 1 and 2 have a small sacral slope (SS) and types 3 and 4 have a large SS. Due to the large correlation between pelvic incidence (PI) and SS, it can be said that types 1 and 2 have a small PI, and 3 and 4 have a large PI [3]. Type 1 is not a harmonious back with a significant thoracic kyphosis and a short hyperlordosis. It is associated with a risk of degenerative disc disease and a risk of spondylolysis of the fifth lumbar vertebra with a “crack nuts” mechanism [3]. Type 2 represents a hypolordotic and hypokyphotic spine. It is a harmonious “flat back” [3,6]. It is also associated with a risk of degenerative disc disease, and particularly a central disc herniation [3]. Types 3 and 4 have a greater lumbar lordosis (LL).
In this case, and particularly for type 4, the main risk is that of L5 spondylolisthesis by a “sliding” mechanism [3]. The type 3 represents a balanced spine between its two curves. It is a harmonious and steady back [6]. The type 4 represents a state of hyperextension. It is a harmonious back with an exaggerated lumbar lordosis. The most important radiographic parameters of the sagittal balance are well defined but few studies present the normal values. The pelvic parameters are the following: pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT). The most important study is that of Thiong [7] which gave normal values in 709 asymptomatic adults. Moreover, there was no difference between men and women. Various other studies have reached the same conclusion [8-10].

Since all these similar studies were targeting the European population, the current study was conducted specifically in Lebanon and describes the lumbar morphotypes among asymptomatic young adults and evaluates pelvic parameters between men and women.

MATERIALS AND METHODS

A cross-sectional study including 95 asymptomatic young adults was conducted during the year 2012-2013 at Hôtel-Dieu de France Hospital in Beirut. This study was approved by the ethics committee.

The volunteers were eligible under the following inclusion criteria:
1) Age > 18 and < 40 years;
2) No history of disco-vertebral pathologies (malformative, degenerative, or traumatic) that may affect the sagittal balance of the spine or the appearance of the lumbar lordosis;
3) No history of musculoskeletal disorders of the lower limbs (degenerative, congenital, or traumatic) that can affect walking;
4) No history of abnormal gait;
5) No history of neuromuscular disorders (cerebral, spinal, radicular, or myopathic);
6) No scoliosis, and
7) No contraindications to radiation exposure (tumor, pregnancy...).

All the participants were between 21 and 30 years old, given the dominance of medical students and residents among the participants. A total of 95 lateral radiographs were done to 95 participants, of which one was excluded because of the discovery of a vertebral slip. The radiographic protocol was standardized. A single machine took a simple lateral X-ray of the lumbar spine in the standing position. Technicians who had received prior training supervised the exact position of the participants. In total, the final sample was composed of 94 radiographs (53 men and 41 women).
Pelvic parameters (Fig. 2) were subsequently measured manually by four people who had received prior training (two interns, a resident in orthopedic surgery and an orthopaedic surgeon) in order to get the most accurate measurements possible.

The pelvic incidence (PI) evaluates the sacropelvic morphology [3]. This value is specific to each individual, and does not vary with age [1,3,6]. It is defined by the angle between the perpendicular to the middle of the sacral plateau and the line joining the center of the sacral plateau to that of the bicoxofemoral axis [3, 7]. PT and SS are two ways of assessing the pelvic balance [7]. They are two positional or functional parameters that vary with age. The PT is the angle between the vertical line and the line joining the middle of the sacral plateau and that of the bicoxofemoral axis; PT simply represents the rotation of the pelvis around the hips. When the pelvis is in a posterior rotation, the PT increases, and vice versa [1,7]. The SS is the angle between the horizontal line and the tangent to the top surface of the sacral plateau. It therefore indicates the orientation of the sacral plateau and pelvis relative to the horizontal line.

To evaluate the variation of these parameters by sex, the sample was divided into 2 groups; one consisting of radiographs representing male participants and included 53 subjects, and another representing the female participants included 41 subjects. The analysis was made by SPSS 17.0 software. Descriptive statistics (mean and standard deviation for each of the 3 pelvic parameters (PP)) had been provided for all participants, as well as for men and women separately. In addition, the confidence interval of selected values is the most used in the studies and includes 95% of the values of the asymptomatic population, estimated from the mean ± 2 standard deviations. Comparisons between men and women were performed for each of the 3 PP, using the Student T-test for two independent samples or bivariate t-test. Radiographs were also classified according to the 4 lumbar morphotypes of Roussouly (Fig. 1). Types 1 and 2 have a small SS (SS < 35°). In type 1, the distal arch of the lumbar lordosis is almost absent, the apex of the LL is very low, located in the center of L5. The LL is almost only formed by the upper arch. There is thus a short LL with a negative lumbar angle of inclination and a long thoracic kyphosis [6]. In type 2, the distal arch is low, longer but relatively flat. The apex is located almost at the L4 base. The inflection point is higher, thereby reducing the angle of inclination but increasing lumbar vertebral number included in the LL. In type 3, the SS is between 35° and 45°. The apex is at L4 center. The lower arch of LL becomes more prominent. The inflection point is at the thoracolumbar junction, and the lumbar angle of inclination approaches zero. The LL includes an average of 4 vertebral bodies. In type 4, the SS is > 45°. The apex is located at the base of L3 or even higher. The lower arch of LL is prominent with a nil or positive angle of inclination. The LL includes more than 5 lumbar vertebrae [6].
RESULTS

The values of the PI, the SS, and the PT follow a normal distribution. Descriptive statistics for each PP is represented in Table I. In particular, this table shows the expected value range in 95% of asymptomatic young adults. The average angle of the SS for the whole sample, males and females, was 39.85° with a maximum of 57° and a minimum of 23°; that of PI angle was 51.34°, a maximum of 78° and a minimum of 33°. Finally, the average, maximum and minimum angle values of PT for the entire sample were 11.11°, 32° and –6°, respectively. The statistical study involved comparing the averages of each angle between males and females. This was done with the “T-test” i.e. Student test. The test did not show a difference between men and women for each of the three angles.

In addition, the classification of lumbar morphotypes of the sample different radiographs showed the following results (Fig. 3): 12 subjects, including 7 males, belonged to type 1 (or 12.76% of total); 19, of which 12 males, to type 2 (20.21%); 42, of which 24 males, to type 3 (44.68%); and 21, including 10 males, to type 4 (22.34%).

DISCUSSION

The primary objective of this study was to classify the Lebanese lumbar morphotypes according to the classification of Roussouly. In fact, Roussouly has published one study in 2005 classifying lumbar morphotypes into four types based on 160 asymptomatic individuals [6]. He found: * 21.25% Type 1 * 11.25% Type 2 * 37.5% Type 3 * 30% Type 4.

Meanwhile, our study showed: * 12.76% Type 1 * 20.21% Type 2 * 44.68% Type 3 * 22.34% Type 4. This in fact has no comparative significance except that type 3, which represents a well-balanced spine, is actually the most common morphotype. On the other hand, more important to note is the prevalence of the other morphotypes among the Lebanese people since they can predict the senile evolution and the degenerative correlated pathologies [1,3]. In other words, types 1 and 2 that represented approximately 33% of our sample are actually individuals at risk of degenerative disc disease and would suffer more back pain. Twenty-two percent (type 4) have a greater risk of spondylolisthesis and lumbar spinal stenosis. [3,6]

As a secondary objective, this study showed no difference among pelvic parameters according to the gender. This is in fact the case of the majority of studies that have tried to see the influence of gender [7-10]. In contrast, the studies that have found a difference between men and women are rare and old [11,12]. Similar studies were conducted in other countries, especially in France and Canada, and in particular that of Thiong and Roussouly in 2011 on 709 asymptomatic adults in which the means of PI, SS and PT angles were 52.6°, 43.2°, and 13° respectively [7]. This study represents to this day the largest cohort in the literature including asymptomatic healthy subjects, and dedicated to the assessment of the sacral pelvic morphology and balance. There is therefore a strong “database” that can be used without doubt as a study reference.

In Lebanon, and based on our study, the average of PI, SS and PT angles for males and females was 51.34°, 39.85° and 11.11° respectively. We can note that the PP values are close by comparing our Lebanese sample to the large cohort conducted recently in France. Other studies show actually almost similar values [6,8,13].

The study has three limitations. The first one is the transversal nature that did not allow us to evaluate the influence of age on lumbar lordosis and pelvic parameters. A longitudinal study will probably be more accurate.

![Figure 3](image-url)
Second, measurements and classifications were made manually. In contrast, Roussouly used the software called “Softimage Spine, Optimage” [6] in his classification, and Thiéng used the “Optispine” software in his measures [7]. This actually is not very important since PP values in our sample were very close to those reported by Thiéng and Roussouly. However, the use of specialized softwares could explain the differences we had in the classification of morphotypes, particularly for morphotypes 1 and 2 since they have the same sacral slope but differ mainly by the apex of the lumbar lordosis. Thus it can show that the software will be more able to localize the exact position of the apex of the LL. The last limitation concerns the sampling since most of the participants were young medical students and this is probably not representative of the Lebanese population.

**CONCLUSION**

The lumbar morphotype is a recent topic in the literature that few authors have addressed. This cross-sectional study suggests that more than 50% of young people in our region are classified outside the morphotype that is the least associated with degenerative spine diseases, i.e. the third morphotype, having the lumbar lordosis most suited to a better postural balance.

It would be more interesting to study the spinal morphotypes of symptomatic individuals (back pain, disc herniation, spondylolisthesis...) to confirm the proposed pathological correlations, or vice versa, could it become a screening tool for various disco-vertebral diseases.

**REFERENCES**