Differences in pelvic parameters among Mexican, Caucasian, and Asian populations

Clinical article

BARÓN ZÁRATE-KALFÓPULOS, M.D.,1 SAMUEL ROMERO-VARGAS, M.D.,1 EDUARDO OTERO-CÁMARA, M.D.,1 VÍCTOR CORREA CORREA, M.D.,1 AND ALEJANDRO REYES-SÁNCHEZ, M.D.2

1Spine Surgery Service, and 2Chief Special Surgery Service, Instituto Nacional de Rehabilitación, Mexico City, Mexico

Object. The aim of this study was to describe the pelvic parameters in a sample of healthy Mexican volunteers and to compare them with previously reported data for Caucasian and Asian populations.

Methods. This was a transversal study that included a sample population of healthy Mexican volunteers. Age, sex, and lateral radiographs of the lumbosacral region with the individual standing to obtain the pelvic parameters of pelvic tilt (PT), sacral slope (SS), pelvic incidence (PI), and lumbar lordosis (LL) were recorded in each volunteer. The data were compared with those previously published for Caucasian and Asian individuals.

Results. In total, 202 Mexican individuals (81 men and 121 women; mean age 46.5 years, range 18–85 years) were included. There were statistically significant differences between the Mexican and Caucasian control group with respect to PT (11.9° vs 15.78°, respectively) and PI (51.91° vs 56.68°, respectively). Comparison with the Asian population showed statistically significant differences in relation to the Mexican group in terms of the PT (11.5° vs 15.78°), PI (47.8° vs 56.68°), and SS (36.3° vs 40.89°). The mean LL was 60.17° for the Mexican group, 52.3° for the Asian group, and 61.3° for the Caucasian group. A significant difference in LL was found between the Mexican and Asian populations (p < 0.0001).

Conclusions. A comparison of the values for pelvic parameters and lumbar lordosis across the different population samples revealed statistically significant differences, which can be attributed to the ethnic origin of the individuals.

Key Words • pelvic tilt • pelvic incidence • sacral slope • ethnic groups • lumbar lordosis

Abbreviations used in this paper: LL = lumbar lordosis; PI = pelvic incidence; PT = pelvic tilt; SS = sacral slope.

MODIFICATIONS of sagittal balance are associated with changes in pelvic orientation.1 Several studies have confirmed that the pelvic parameters determine the lumbar lordosis and sagittal balance of the spine in healthy individuals. In addition, they have a significant role in the development of some adult spine disorders, such as spondylolisthesis,6,16,22

These pelvic parameters can be radiographically analyzed in the sagittal plane using 3 well-defined angular measurements: PT, SS, and PI. The PT is defined as the angle between the vertical plane and the line that travels through the midpoint of the sacral platform toward the center of the femoral heads. The SS is the angle between the horizontal plane and the sacral platform. The PI is defined as the angle between the perpendicular of the sacral platform at its midpoint and the line that connects this point with the femoral heads. The 3 pelvic parameters are geographically related, since they share anatomical landmarks, such that the sum of the PT and SS is the PI.16

Measurements of the pelvic parameters have been documented in Caucasian2,4–6,8,9 and Asian15 populations of healthy volunteers (Tables 1 and 2). Differences in 3 of 6 of the sagittal plane parameters have been documented between black and white individuals with respect to adolescent idiopathic scoliosis.17 Ethnic differences are a significant factor not only when describing the anthropometric data but also when applying the findings to a different
ethnic group. Given the importance of the spinopelvic parameters, there is a need to describe the parameters differentially in relation to the ethnicity of the studied individual.

The aims of the present study were to describe the pelvic parameters in a sample of healthy Mexican volunteers and to compare these results with those previously reported for Caucasian and Asian populations.

Methods

Patient Selection

This was a transversal study that included a sample of 202 healthy Mexican volunteers who had to be the descendants of Mexican parents and grandparents on both the maternal and paternal branches/lines. Excluded from the study were those who had any kind of spine or hip surgery, were carriers of any type of musculoskeletal syndrome, or had a pelvic limb discrepancy (2 cm).

The following items of information were collected from each volunteer: age, sex, and lateral radiographs of the lumbosacral region with the individual standing, so as to obtain the pelvic parameters of PT, SS, PI, and LL.

The study was conducted in the service of spinal surgery at our center with the approval of the Research and Bioethics Committee. Informed consent for participation in the study was obtained from all volunteers.

Radiological Evaluation

A similar radiographic protocol was used for all volunteers. Each volunteer underwent a 30 × 90–cm lateral radiography of the lumbosacral region, printed on acetate with the individual standing, knees extended, and flexed arms in front. Care was taken to ensure that the radiography included both femoral heads. If the femoral heads did not overlap in the radiograph, the midpoint of the line connecting the isocenter of both femoral heads was taken as a reference point.

The radiological parameters of PT, SS, and PI, which are expressed as angles, were derived for each volunteer.

Results

The inter- and intraobserver concordances were calculated for each measured parameter. Both were found to be excellent, giving intraclass correlation coefficients of 0.97 (0.89–1.00) and 0.97 (0.88–1.00), thereby demonstrating intra- and interobserver reliability, respectively.

In total, 202 Mexican patients were included in the study. There were 81 men (40%) and 121 women (60%) who ranged in age from 18 to 85 years (mean 46.5 years). The data for our sample population represented a normal distribution (gaussian). Table 1 shows the angular values for the pelvic parameters in the Mexican population. These values were compared with those for the Caucasian control group, which comprised 160 healthy individuals (86 women and 74 men; mean age 27 years) (Table 2).

The mean values for PT (15.78° vs 11.99°), respectively and PI (56.68° vs 51.91°) were higher in the Mexican group than in the Caucasian control group, whereas the values for SS (40.89° vs 39.92°) and LL (60.17° vs 61.3°) were not significantly different between these 2 groups (p > 0.05). The comparison shows statistically significant differences between the groups for PT (95% CI -5.3714° to -2.2086°, p < 0.0001). The mean PI value was also higher in the Mexican group (95% CI -7.3230° to -2.2170°, p < 0.0003).

The mean age of 28 years (range 19–38 years) and an average weight of 64 kg. The values for the pelvic parameters of this group are summarized in Table 3. Comparisons of the mean values for the Asian and Mexican populations revealed differences for PT (11.5° vs 15.78°), SS (36.3° vs 40.89°), PI (47.8° vs 56.68°), and LL (52.3° vs 60.17°) (95% CI 4.66°–11.07°, p < 0.0001).

The statistical analyses showed significant differences for each pelvic parameter: PT (95% CI 6.2071° to -2.3529°, p < 0.0001); SS (95% CI -7.0847° to -2.0953°, p < 0.0003); LL was measured from T-12 to the sacral endplate. The measurements were performed manually on 2 separate occasions by 2 independent individuals who are experts in spine surgery (E.O.C. and S.R.V.), using a manual technique with the radiograph placed on an LED light Negascope. The inter- and intraobserver concordances were calculated.

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The mean values for PT (15.78° vs 11.99°), respectively and PI (56.68° vs 51.91°) were higher in the Mexican group than in the Caucasian control group, whereas the values for SS (40.89° vs 39.92°) and LL (60.17° vs 61.3°) were not significantly different between these 2 groups (p > 0.05). The comparison shows statistically significant differences between the groups for PT (95% CI -5.3714° to -2.2086°, p < 0.0001). The mean PI value was also higher in the Mexican group (95% CI -7.3230° to -2.2170°, p < 0.0003).

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The statistical analyses showed significant differences for each pelvic parameter: PT (95% CI 6.2071° to -2.3529°, p < 0.0001); SS (95% CI -7.0847° to -2.0953°, p < 0.0003);
and PI (95% CI -11.9977° to -5.7623°, p < 0.0001). Comparing the means of the 3 groups, statistically significant differences were noted for the 3 pelvic parameters (p < 0.005).

To ensure an accurate comparison, taking into account the mean ages of the groups, we performed a subanalysis with 35 patients from our sample group, with a mean age of 30.4 years (range 18–41 years) (Table 4).

Interestingly, when we compared the pelvic parameters between Caucasians and the Mexican Mestizo population, the differences in the PT and PI parameters lost the previously observed significance, while comparison of the SS values showed significant differences (39.92° vs 43.6° for Caucasians and Mexicans, respectively; p = 0.04). In the comparative subanalysis of the Mexican and Asian populations, all the differences noted previously for the pelvic parameters, with the exception of PT, retained statistical significance. In the multivariate analysis, the only pelvic parameter that was different among the 3 different ethnic groups was the SS (p < 0.05).

**Discussion**

Ethnicity plays an important role in the differentiation of anthropometric values. Multiple differences in the physical constitution of interracial origin have been previously described. The Mexican Mestizo is a Latino admixed population comprising Amerindian, European, and, to a lesser extent, African ancestries. Despite its genetic diversity, the Mexican Mestizo population is a useful resource, even for genomic studies, as it represents the genetic variability that is lacking in other continental groups.

To ensure that our studied population was of Mexican origin, we used the criteria that are used in genomic studies, whereby each volunteer was required to have all 4 grandparents born in Mexico. The importance of pelvic parameters lies in describing the anatomical shape and position of the sacrum with respect to the pelvis and the influences on the positional configuration and the sagittal alignment of the spine. The pelvic parameters have been associated with the etiologies of various spine disorders, and some authors have suggested that higher PI values predispose individuals to the development of spondylolisthesis.

In clinical practice, the pelvic parameters are of cardinal importance. However, the reference values used came from transversal descriptions in Caucasian and Asian individuals.

The results of the present study show that the pelvic parameters are highly variable among individuals in this sample of 202 individuals and in the control groups, with a wide range of angular values being recorded. Although reference values defined as “normal” have been reported, we believe that this constitutes a simplistic view of the variability observed for individual anthropometric values.

Comparing the values of the Mexican and Caucasian groups, we observed that the PI and PT values were higher in the former group. This may be explained by the geometric and interdependent relationships between the pelvic parameters. The following anatomical interpretation is offered: if the femoral heads are placed in a relatively anterior position, the PT value will become higher without affecting the SS value, whereas the total value of PI will be changed.

Taking the Asian group as the reference, we observed a remarkable increase in the angular values for the pelvic parameters. The authors of the study on the Korean sample provided information on the average weight of the studied population (64 kg), whereas the corresponding value for our group was 72 kg. To attribute the observed differences to weight or body mass index would merely be speculation, given the cross-sectional design of both studies. However, we can state that there were statistically significant differences between the different ethnic groups studied.

Other researchers have shown differences in sagittal parameters between different races. Hanson and colleagues found significantly greater lumbosacral curvature in blacks than in whites. Similarly, Lonner et al. found significant differences between black and white patients with adult idiopathic scoliosis and showed that the PI, PT, and LL values were higher in the black group. These authors concluded that race might influence the individual spinopelvic alignment.

Although there are notable and characteristic changes in the sagittal alignment of the spine with aging, pelvic parameters show minimal variability over the years, as described in recent publications. We recognize the differences in the mean ages of the compared groups and that our patients were older. However, we do not think that this explains the significant differences observed for the angular values of the 2 groups.

This study constitutes the first description of the pelvic parameters in a population of Mexican individuals, and it reveals differences in the values for pelvic parameters that may be attributable to ethnicity. Regardless of the cause of the differences, the data presented serve as a reference for clinical practice in our environment.

Our results suggest that race influences the individual

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**TABLE 3: Pelvic parameters in a sample of 86 healthy Asian individuals**

<table>
<thead>
<tr>
<th>Pelvic Parameter</th>
<th>Measurement (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>PT</td>
<td>11.5 ± 5.3</td>
</tr>
<tr>
<td>SS</td>
<td>36.3 ± 7.8</td>
</tr>
<tr>
<td>PI</td>
<td>47.8 ± 9.3</td>
</tr>
</tbody>
</table>

**TABLE 4: Pelvic parameters among the different ethnic groups**

<table>
<thead>
<tr>
<th>Pelvic Parameter</th>
<th>Mexican Mestizo*</th>
<th>Caucasian</th>
<th>p Value (vs Caucasian)</th>
<th>Asian</th>
<th>p Value (vs Asian)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT</td>
<td>12.0°</td>
<td>11.99°</td>
<td>0.994</td>
<td>11.5°</td>
<td>0.695</td>
</tr>
<tr>
<td>SS</td>
<td>43.6°</td>
<td>39.92°</td>
<td>0.04†</td>
<td>36.3°</td>
<td>0.00†</td>
</tr>
<tr>
<td>PI</td>
<td>55.6°</td>
<td>51.91°</td>
<td>0.11</td>
<td>47.8°</td>
<td>0.00†</td>
</tr>
<tr>
<td>LL</td>
<td>63.8°</td>
<td>61.43°</td>
<td>0.278</td>
<td>52.3°</td>
<td>0.00†</td>
</tr>
</tbody>
</table>

* For this group, the mean age is 30 years.
† Statistically significant.
spinopelvic alignment and is a factor to take into account when planning surgical reconstruction. Further research is needed to explore other parameters, such as the total sagittal alignment of the entire spine, to identify ethnic differences.

Conclusions

In comparing the values for pelvic parameters and lumbar lordosis of the different analyzed population samples, we found statistically significant differences that can be attributed to ethnicity.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Zárate-Kalfópulos, Romero-Vargas. Acquisition of data: Romero-Vargas, Otero-Cámara, Correa. Analysis and interpretation of data: Zárate-Kalfópulos, Romero-Vargas. Drafting the article: Zárate-Kalfópulos. Critically revising the article: Zárate-Kalfópulos, Romero-Vargas, Otero-Cámara. Reviewed submitted version of manuscript: Zárate-Kalfópulos. Approved the final version of the manuscript on behalf of all authors: Zárate-Kalfópulos. Statistical analysis: Romero-Vargas. Administrative/technical/material support: Reyes-Sánchez. Study supervision: Reyes-Sánchez.

References