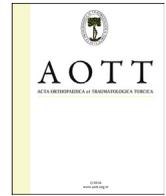


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Evaluation of symphysis pubis and sacroiliac joint distances in skeletally immature patients: A computerized tomography study of 1020 individuals



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ABSTRACT

Objective: The aim of this study was to create a reference about normal pubic symphysis and sacroiliac joint widths of children and adolescents.

Methods: A total of 1020 computerized tomography axial scans of patients without pelvic injury between 2 and 18 year-old were studied. The narrowest width of pubic symphysis and bilateral sacroiliac joints were measured.

Results: The average pubic symphyseal width at 2 years old boys was 6.35 ± 1.06 mm (4.88–9.13 mm). The average of right and left sacroiliac joints' widths at 2 years old boys was 4.56 ± 0.65 mm (3.59–6.07 mm) and 4.58 ± 0.66 mm (3.44–5.74 mm), respectively. The average pubic symphyseal width of 2 years old girls was 5.85 ± 1.14 mm (4.06–8.20 mm). The average of right and left sacroiliac joints' widths at 2 years old girls was found 4.36 ± 0.56 mm (3.50–5.37 mm) and 4.42 ± 0.59 mm (3.58–5.73 mm), respectively. The average pubic symphyseal width at 18 years old boys was found 3.68 ± 1.30 mm (1.90–5.79 mm). The average of right and left sacroiliac joints' widths at 18 years old boys was found 1.97 ± 0.21 mm (1.73–2.41 mm) and 2.04 ± 0.30 mm (1.70–2.65 mm), respectively. The average pubic symphyseal width at 18 years old girls was 3.92 ± 0.52 mm (2.97–4.76 mm). The average of right and left sacroiliac joints' widths at 18 years old girls was found 2.34 ± 0.40 mm (1.58–3.34 mm) and 2.33 ± 0.37 mm (1.58–3.10 mm), respectively.

Conclusion: Our results suggest that one should be suspicious about pelvic injury if the width of pubic symphysis is over 10 mm and width of sacroiliac joint is over 8 mm especially in patients younger than 10 years-old.

Level of Evidence: Level III Diagnostic study.

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Introduction

Pelvic girdle injuries are one of the most devastating injuries in both children and adults. Evaluation of widths of the pubic symphysis and sacroiliac joint is considered as a standard radiologic diagnostic tool on either radiograph or computerized tomography scan (CT) for pelvic injuries.^{1,2} Pubic symphysis width more than 25 millimeters (mm) is accepted as a cut off value about rotational

instability of innominate bones in adults.³ But there is not enough data about normal values in the current literature. In pediatric population it is more difficult to evaluate these distances because of cartilage nature of the growing bone.

To our knowledge there are only two studies in which pubic symphysis widths were measured by CT in the literature.^{4,5} One of these studies is about pediatric population and the other one is about adult population. The study about pediatric population was performed by a limited patient number (140 patients).⁴ Very recently sacroiliac joint's width was studied on 427 CT scans.⁶ In this study we aimed to assess the normal values of pubic symphysis and sacroiliac joint's width in 1020 pediatric and adolescent subject of our country.

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Material and methods

Patients with lower abdomen and pelvic CT between January 2009 and December 2015 were evaluated from the hospital's digital database. Inclusion criteria were; CT images which contained both pubic symphysis and sacroiliac joints, patients younger than nineteen years old and older than one year old. Exclusion criteria were; CT images without centimeter scanograms and patients with a pelvic trauma etiology. There were totally 14768 CT images and 1747 of them were belonging to the patients who were between 2 and 18 years old (2 and 18 years are included) which were not performed for trauma etiology. To achieve a standardization about patient number according to their ages and gender, 60 patients (30 female and 30 male) were randomly selected and included in each age group. Overall CT scans of 1020 patients were included into the study.

CT scans were performed as 2 millimeter (mm) axial slices. The narrowest width of pubic symphysis, right-left sacroiliac joints' were measured by using Picture Archiving Communication System's (PACS) measurement tool on axial CT scans. The centimeter scanogram of the related image was measured and the magnification risk was avoided by using correct proportions method (Fig. 1a and b). The measurement was performed by a single orthopedic surgeon.

Statistical Package for Social Sciences (SPSS) version 21 for Windows was used to calculate mean, standard deviation and minimal-maximal values. T test was used to compare the values of pubic symphyseal width and right-left sacroiliac joints' width between age of 2 years and 18 years for each gender.

Results

The average pubic symphyseal width at two years-old was 6.35 ± 1.06 (4.88–9.13) mm and 5.85 ± 1.14 (4.06–8.20) mm for

boys and girls, respectively. The average right sacroiliac joint width at two years-old was 4.56 ± 0.65 (3.59–6.07) mm and 4.36 ± 0.56 (3.50–5.37) mm for boys and girls, respectively. The average left sacroiliac joint width at two years-old was 4.58 ± 0.66 (3.44–5.74) mm and 4.42 ± 0.59 (3.58–5.73) mm for boys and girls, respectively.

The average pubic symphyseal width at 18 years-old was 3.68 ± 1.30 (1.90–5.79) mm and 3.92 ± 0.52 (2.97–4.76) mm for boys and girls, respectively. The average right sacroiliac joint width at 18 years-old was 1.97 ± 0.21 (1.73–2.41) mm and 2.34 ± 0.40 (1.58–3.34) mm for boys and girls, respectively. The average left sacroiliac joint width at 18 years-old was 2.04 ± 0.30 (1.70–2.65) mm and 2.33 ± 0.37 (1.58–3.10) mm for boys and girls, respectively. As a result of T test whole values had decreased statistically significantly ($p < 0.001$ for all values). Patients were also subgrouped as 2–5, 6–10 and 11–18 years old (Table 2).

It was observed that symphysis pubis and sacroiliac joint widths were narrowed at seven years old (Table 1). These differences were statistically significant ($p < 0.001$, about boys' symphysis, right and left sacroiliac joint widths and $p: 0.002$ and $p: 0.003$, for right and left sacroiliac joint widths of females, respectively) except the difference between symphysis pubis widths of females ($p: 0.25$).

It was evident that whole joint widths were decreased after twelve years old. These differences were statistically significant for whole differences (Table 3).

It was observed that whole widths are narrowed by skeletal maturation as expected. The values of each age group according to gender are listed in Table 1 and are also shown in Fig. 2a–c.

Discussion

In this study, the widths of pubic symphysis and both sacroiliac joints are evaluated and described as a reference standard for children and adolescents of Turkish population who did not have a pelvic injury. Pubic symphysis width was measured as high as 9.13 mm in males and 9.78 mm in females. Sacroiliac joint width was measured as high as 7.78 mm in males and 6.85 mm in females. It was evident that pubic symphysis and sacroiliac joint widths are narrowed by skeletal maturation.

In 1993 and 2005 Patel and McAlister et al, respectively have evaluated normal pubic symphyseal width in pediatric patients.^{7,8} However, these two studies were based on nonstandardized anteroposterior pelvic radiographs. Patel et al's study included 888 consecutive radiographs whereas McAlister et al included 238 consecutive pelvic radiographs. It was concluded that one should be suspicious of possible pelvic injury if pubic symphyseal width was above 8.4 mm and below 5.2 mm.⁸ Although McAlister et al have used an electronically calibrated distance-measuring tool, the most important limitation of these studies were that correction of magnification on conventional radiographs are difficult and measurement of pubic symphyseal width can be changed even in small amount of rotation of the pelvis.

Nejad et al were first to evaluate pubic symphyseal width of pediatric population on CT.⁴ The authors performed the measurements on axial CT images of 140 patients aged between 2 and 15 years. It was concluded that pubic symphyseal width could be as high as 9.2 mm. The other important finding of this study was that males had a wider pubic symphysis than females of the same age group and this distance decreased from infancy toward skeletal maturity. In our analysis we measured pubic symphysis as high as 9.78 mm. In our study group it was also observed that males had wider pubic symphysis than females (Fig. 2a). And similarly pubic symphysis width narrowed by maturation. There was a consistent trend towards reduction of width in all measurements after age of 12 years. It could be related to skeletal maturity.

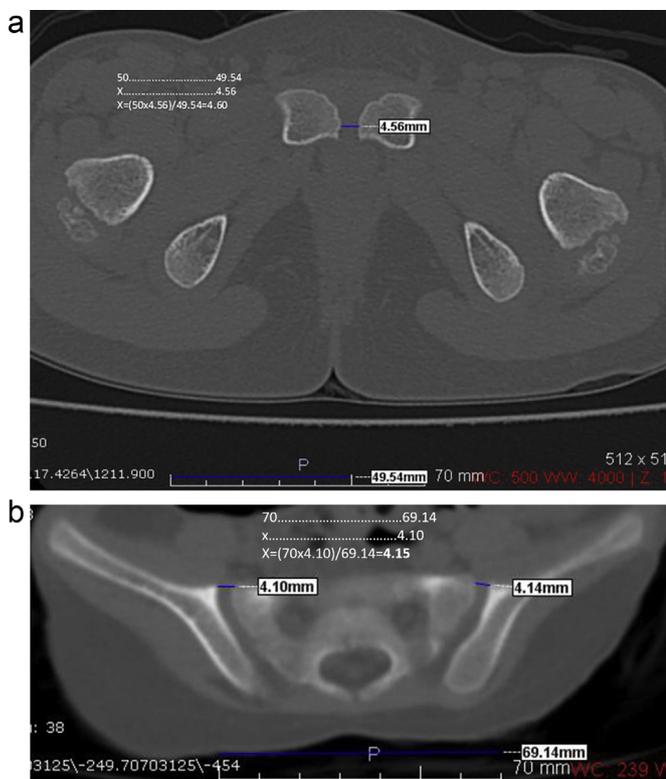


Fig. 1. a. Measurement method of pubic symphyseal width and applying correct proportions method for measurement. b. Measurement method of sacroiliac joints.

Table 1
Values of pubic symphysis, right sacroiliac joint, left sacroiliac joint width for each gender and ages between 2 and 18.

| | Male | | | Female | | |
|----------|---|--|---|---|--|---|
| | Symphysis pubis width mean \pm std. dev. (min–max) (mm) (n: 30) | Right sacroiliac joint width mean \pm std. dev. (min–max) (mm) (n: 30) | Left sacroiliac joint width mean \pm std. dev. (min–max) (mm) (n: 30) | Symphysis pubis width mean \pm std. dev. (min–max) (mm) (n: 30) | Right sacroiliac joint width mean \pm std. dev. (min–max) (mm) (n: 30) | Left sacroiliac joint width mean \pm std. dev. (min–max) (mm) (n: 30) |
| 2 years | 6.35 \pm 1.06 (4.88–9.13) | 4.56 \pm 0.65 (3.59–6.07) | 4.58 \pm 0.66 (3.44–5.74) | 5.85 \pm 1.14 (4.06–8.20) | 4.36 \pm 0.56 (3.50–5.37) | 4.42 \pm 0.59 (3.58–5.73) |
| 3 years | 5.87 \pm 0.83 (4.61–7.45) | 5.11 \pm 1.05 (3.62–7.78) | 5.02 \pm 0.78 (4.01–7.17) | 6.12 \pm 1.08 (4.16–8.63) | 4.68 \pm 0.80 (3.47–6.82) | 4.73 \pm 0.71 (3.31–6.64) |
| 4 years | 5.72 \pm 0.92 (4.25–8.75) | 4.83 \pm 0.98 (2.80–6.13) | 4.79 \pm 1.01 (3.06–6.85) | 6.02 \pm 1.20 (4.25–9.78) | 4.80 \pm 0.92 (2.80–6.62) | 4.75 \pm 0.90 (3.06–6.85) |
| 5 years | 5.88 \pm 0.74 (4.66–7.27) | 4.81 \pm 0.95 (3.00–6.39) | 5.09 \pm 0.90 (3.76–6.58) | 5.91 \pm 0.93 (4.54–8.74) | 4.75 \pm 0.85 (3.00–6.39) | 4.81 \pm 0.79 (3.58–6.58) |
| 6 years | 5.59 \pm 1.14 (3.37–7.76) | 4.92 \pm 0.64 (3.55–5.95) | 5.04 \pm 0.49 (4.21–5.97) | 5.31 \pm 1.19 (3.12–8.31) | 4.26 \pm 0.78 (2.86–6.21) | 4.13 \pm 0.98 (2.33–5.11) |
| 7 years | 4.39 \pm 0.86 (2.16–5.70) | 3.69 \pm 0.85 (2.15–6.16) | 3.71 \pm 0.89 (2.20–6.20) | 4.93 \pm 1.17 (3.45–8.33) | 3.54 \pm 0.65 (2.59–5.07) | 3.61 \pm 0.75 (2.60–5.75) |
| 8 years | 5.57 \pm 1.12 (3.86–8.00) | 4.89 \pm 0.84 (3.43–7.06) | 5.01 \pm 0.85 (3.29–7.34) | 5.09 \pm 1.19 (3.22–7.36) | 4.5 \pm 0.84 (3.15–6.45) | 4.37 \pm 0.87 (3.15–6.45) |
| 9 years | 5.68 \pm 1.07 (3.89–8.77) | 5.06 \pm 0.78 (3.67–6.57) | 5.25 \pm 0.90 (3.42–7.16) | 5.31 \pm 1.06 (3.76–7.30) | 3.90 \pm 0.91 (2.53–5.55) | 4.26 \pm 0.98 (3.06–5.92) |
| 10 years | 5.66 \pm 1.08 (4.10–8.20) | 5.05 \pm 0.84 (3.18–6.63) | 5.09 \pm 0.74 (3.64–6.81) | 5.23 \pm 0.87 (3.77–7.39) | 4.84 \pm 0.88 (2.94–6.37) | 4.86 \pm 0.84 (3.26–6.61) |
| 11 years | 6.18 \pm 0.80 (4.90–7.95) | 4.71 \pm 0.38 (3.98–5.48) | 4.71 \pm 0.39 (3.98–5.48) | 6.12 \pm 0.99 (4.73–8.71) | 4.67 \pm 0.53 (3.75–6.00) | 4.68 \pm 0.52 (3.80–6.00) |
| 12 years | 6.24 \pm 0.52 (5.28–7.50) | 5.13 \pm 0.69 (4.00–6.67) | 5.12 \pm 0.71 (4.00–6.70) | 6.02 \pm 0.74 (4.66–7.80) | 4.75 \pm 0.43 (4.00–5.50) | 4.75 \pm 0.43 (4.00–5.50) |
| 13 years | 5.65 \pm 0.77 (4.31–7.27) | 4.14 \pm 0.69 (2.58–5.21) | 4.22 \pm 0.85 (2.34–5.95) | 4.29 \pm 0.72 (3.32–5.76) | 3.19 \pm 0.62 (2.28–4.26) | 3.22 \pm 0.46 (2.42–3.97) |
| 14 years | 5.83 \pm 0.90 (4.10–7.68) | 4.32 \pm 1.22 (2.05–6.63) | 4.43 \pm 1.00 (2.85–6.11) | 4.36 \pm 0.98 (2.58–6.56) | 3.21 \pm 1.12 (1.50–5.88) | 3.29 \pm 0.96 (1.52–5.22) |
| 15 years | 4.67 \pm 1.09 (2.59–7.35) | 3.64 \pm 0.69 (2.59–4.93) | 3.73 \pm 0.93 (2.07–6.25) | 4.08 \pm 0.68 (2.58–5.51) | 2.92 \pm 0.70 (1.58–4.47) | 2.95 \pm 0.76 (1.58–4.74) |
| 16 years | 3.77 \pm 0.95 (1.54–5.56) | 2.17 \pm 0.34 (1.24–2.64) | 2.23 \pm 0.34 (1.51–2.73) | 3.85 \pm 0.65 (2.34–4.76) | 2.20 \pm 0.36 (1.46–2.80) | 2.19 \pm 0.36 (1.46–2.59) |
| 17 years | 3.87 \pm 0.90 (2.12–5.71) | 2.11 \pm 0.33 (1.47–2.86) | 2.12 \pm 0.34 (1.50–2.97) | 3.54 \pm 0.59 (2.32–4.68) | 2.11 \pm 0.36 (1.51–2.96) | 2.16 \pm 0.35 (1.58–2.96) |
| 18 years | 3.68 \pm 1.30 (1.90–5.79) | 1.97 \pm 0.21 (1.73–2.41) | 2.04 \pm 0.30 (1.70–2.65) | 3.92 \pm 0.52 (2.97–4.76) | 2.34 \pm 0.40 (1.58–3.34) | 2.33 \pm 0.37 (1.58–3.10) |

Std. dev.: standard deviation, min: minimum, max: maximum, mm: millimeters.

Table 2
Values of pubic symphysis and right-left sacroiliac joint widths of subgroups.

| | Male (n: 30 per each years) | | | Female (n: 30 per each years) | | |
|-------------|--|---|--|--|---|--|
| | Symphysis pubis width mean \pm std. dev. (min–max) | Right sacroiliac joint width mean \pm std. dev. (min–max) | Left sacroiliac joint width mean \pm std. dev. (min–max) | Symphysis pubis width mean \pm std. dev. (min–max) | Right sacroiliac joint width mean \pm std. dev. (min–max) | Left sacroiliac joint width Mean \pm std. dev. (min–max) |
| 2–5 years | 5.95 \pm 1.71 (4.25–9.13) | 4.82 \pm 1.12 (2.80–7.78) | 4.87 \pm 1.13 (3.06–7.17) | 5.97 \pm 1.42 (4.06–9.78) | 4.64 \pm 1.78 (2.80–6.82) | 4.67 \pm 1.22 (3.06–6.85) |
| 6–10 years | 5.38 \pm 1.05 (2.16–8.77) | 4.72 \pm 1.06 (2.15–7.06) | 4.82 \pm 1.32 (2.20–7.34) | 5.17 \pm 2.02 (3.12–8.33) | 4.20 \pm 1.87 (2.53–6.45) | 4.24 \pm 1.37 (2.33–6.61) |
| 11–18 years | 4.98 \pm 1.22 (2.12–7.95) | 3.52 \pm 1.24 (1.24–6.67) | 3.57 \pm 1.62 (1.50–6.70) | 4.52 \pm 2.06 (2.32–8.71) | 3.17 \pm 1.54 (1.46–6.00) | 3.19 \pm 1.53 (1.46–6.00) |

Table 3
Differences of width values younger and older than 12 years old.

| | Male (n: 30 per each years) | | | Female (n: 30 per each years) | | |
|-------------|--|---|--|--|---|--|
| | Symphysis pubis width mean \pm std. dev. (min–max) | Right sacroiliac joint width mean \pm std. dev. (min–max) | Left sacroiliac joint width mean \pm std. dev. (min–max) | Symphysis pubis width mean \pm std. dev. (min–max) | Right sacroiliac joint width mean \pm std. dev. (min–max) | Left sacroiliac joint width mean \pm std. dev. (min–max) |
| 2–12 years | 5.74 \pm 1.86 (2.16–9.13) | 4.79 \pm 1.78 (2.15–7.78) | 4.85 \pm 1.42 (2.20–7.34) | 5.63 \pm 1.75 (3.12–9.78) | 4.46 \pm 1.15 (2.53–6.82) | 4.48 \pm 1.27 (1.52–6.85) |
| 13–18 years | 4.58 \pm 1.57 (1.54–7.68) | 3.05 \pm 1.12 (1.24–6.63) | 3.13 \pm 1.04 (1.50–6.25) | 4.01 \pm 1.84 (2.32–6.56) | 2.66 \pm 1.34 (1.46–5.8) | 2.69 \pm 1.41 (1.46–5.22) |
| *p values | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

*Student T test.

Evaluation of the sacroiliac joint widths of pediatric pelvis is crucial in determination of the posterior pelvic injuries since patients with these type injuries are reported to require more blood transfusion than isolated anterior pelvic ring injury.⁹ Normal values of sacroiliac joint width were reported firstly very recently.⁶ Normal sacroiliac joint width was reported as meanly 4.7 mm for females and 5.0 mm for males who were under 5 years-old. Normal sacroiliac joint width decreased meanly 2.8 mm for females and 3.1 mm for males who were 16–17 years-old, respectively. Since our results were similar for the patients who were under 5 years-old, we observed that sacroiliac joint widths were narrower for 16–17 years-old (around 2.1–2.2 mm for both males and females). Comparison of the widths of sacroiliac joints could lead confusion because of the possibility of bilaterally injury.

Because of the cartilage nature of growing bone, using magnetic resonance imaging (MRI) to evaluate pubic symphysis and sacroiliac joints' widths can result in more accurate results. There is no

study which has used MRI to evaluate aforementioned distances. Likewise this is our studies' most important limitation. The other important limitation is that the distances were measured by only one single orthopedic surgeon. If the measurements were performed by more than a single surgeon, interobserver reliability could be determined. This current study have some strengths such as the included large and standardized patient number and performance of the measurements by a single orthopedic surgeon. The measurements' accuracy were tried to be upgraded by using centimeter scanograms of the CT images in accordance with digital measurement device.

In conclusion; this study have provided a reference standard for both pubic symphyseal and sacroiliac joint widths for patients under 19 years-old and older than one year-old. We can state that one should be suspicious about pelvic injury if the width of pubic symphysis is over than 10 mm and width of sacroiliac joint is over than 8 mm especially in patients who are younger than 10 years-

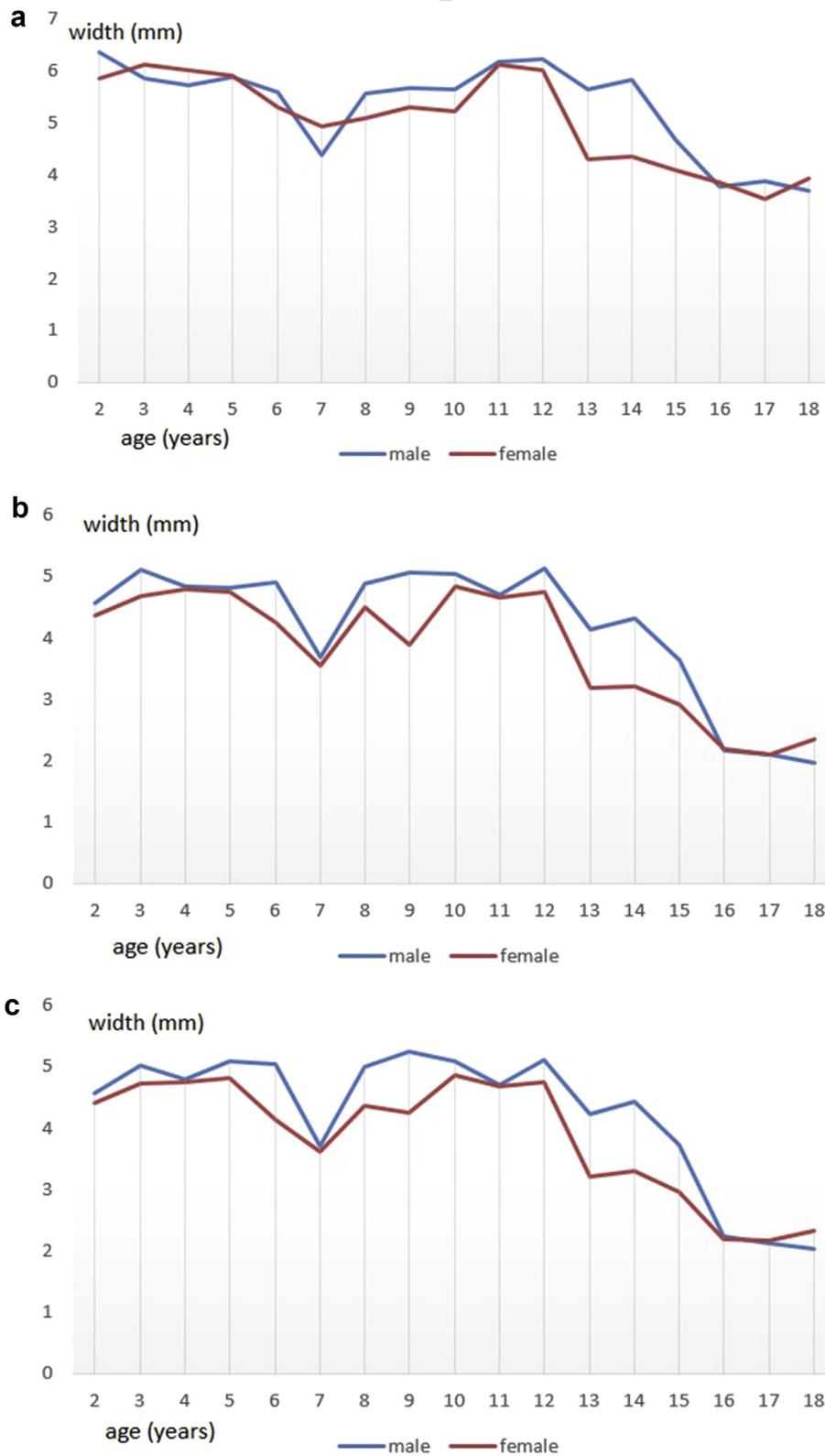


Fig. 2. a. Results of pubic symphyseal width measurement according to ages and gender. b. Results of right sacroiliac joint width measurement according to ages and gender. c. Results of left sacroiliac joint width measurement according to ages and gender.

old. Further studies which evaluate pelvic MRI can give more accurate results.

Conflict of interest

None.

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