



Research Article

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## Assessment of Pelvic Shape by a Newly Developed Posture Analyzer in Young Women in Japan

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### Abstract

**Background:** Body composition has been changing along with change in the life style environment but there have been no studies on pelvic size by objective anthropometric assessment in young Japanese women. The objective was to examine pelvic shape by measuring the angle of inclination (AOI) and the distance between right and left anterior superior (AS) iliac spines. We also investigated associations of these measurements with physical symptoms related to distortion of the pelvis in young Japanese women.

**Methods:** The AOI and the distance between right and left AS iliac spines in 92 female undergraduate students were measured by using a newly developed posture analyzer with a self-administered questionnaire.

**Results:** The mean values of AOI and distance between right and left AS iliac spines were 0.31 radian and 270.1 mm, respectively. The distance between right and left AS iliac spines showed significant positive associations with body weight and height. According to tertiles of AOI, a large percentage of the subjects with a large AOI responded positively to the item "Heights of the fingers of the right and left hands being different when the upper limbs are raised". According to tertiles of distance between right and left AS iliac spines, a large percentage of the subjects with a large distance responded positively to the item "Unhealed past injury in lower legs" and the item "Sitting with one's legs folded sideways".

**Conclusion:** Increase in body weight and height were shown to be associated with pelvic shape. It has also shown that change in pelvic size can be estimated by the item "Heights of the fingers of the right and left hands being different when the upper limbs are raised".

### Keywords

Young women; Pelvic shape; Japanese

### Introduction

Body constitution in young Japanese women has been changing along with change in the life style environment including dietary life. Body height has increased and body shape has become slimmer [1]. The change in body constitution may influence pelvic size. Since it

has been reported that body height was associated with pelvic size [2], pelvic size may be increasing with increase in body height. Also, Watanabe [3] reported that development of the hip bone was associated with development of the pelvic cavity. It has been reported that the intertrochanteric distance, the distance between bilateral iliac spines and the intercrystal distance in parturient women in Croatia during the period from 2007 to 2009 were significantly larger than those in parturient women during the period from 1992 to 1994, suggesting that pelvic shape has changed over the 25-year period [4]. However, to the best of our knowledge, there have been no studies on pelvic size by objective anthropometric assessment in young Japanese women.

Measurement of the pelvic cavity by using radiography is useful as an objective assessment, but radiological exposure is a serious problem, particularly for young women. Therefore, measurements have been done by using pelvimetry and a goniometer. Mitani [5] reported that measurement by the angle of pelvic inclination on the surface of the body is useful since values of pelvic angle obtained by making a line connecting the anterior superior iliac spine to the anterior posterior iliac spine and a horizontal line measured by using a goniometer were correlated with values determined by using radiography.

An association of angle of pelvic inclination with presence of lumbar pain has been suggested. It has been reported that increase in the lordotic angle of lumbar vertebrae was found in male and female undergraduate students with wide angles of pelvic inclination and that these students were likely to complain of lumbar pain [5]. Lim [6] reported that subjects with low back pain had a significantly greater pelvic tilt angle than did those with healthy backs. In Japan, the proportion of lumbago in symptoms that women complained of was high, and it increased with advance of age [7]. Also, Hirata [8] suggested that the change to a slim body shape might be associated with increase in the number of women who complained of menstrual disorders. However, to the best of our knowledge, an association of menstrual disorders with angle of pelvic inclination in young women has not been reported.

Recently, the usefulness of measurement using an image of the subject taken with a digital camera as an objective indicator has been examined in pregnant women [9,10]. In this study, using a newly developed posture analyzer, we examined pelvic shape by measuring the angle of pelvic inclination and the distance between right and left anterior superior iliac spines in young Japanese women. We also investigated the associations of these measurements with physical symptoms related to distortion of the pelvis and menstruation-related factors.

### Methods

This study was conducted from December in 2012 to December in 2013. We recruited 92 female students in Kagawa Prefectural University of Health Sciences. Participants were informed of the purposes and procedure of the study.

### Questionnaire

We designed a self-administered questionnaire consisting of three parts that took about 20 minutes to complete. The first part

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of the questionnaire consisted of questions regarding baseline characteristics, including body height and body weight for calculating body mass index (BMI) and menstruation-related factors including age of menarche, menstrual cycle, menstrual duration and presence of menstrual pain. The second part of the questionnaire consisted of questions on the presence of physical symptoms such as headache, lumbar pain, sensitivity to cold and shoulder stiffness. The third part consisted of questions on positions of pelvic distortion and signs of pelvic distortion. There were 9 questions regarding positions of pelvic distortion and 10 questions regarding signs of pelvic distortion based on a previous report [11]. The items regarding positions of pelvic distortion included (1) unhealed past injury in lower legs, (2) bowlegs from childhood, (3) flat feet, (4) rounded shoulders, (5) weak muscles in the abdomen and back, (6) habit of crossing the legs, (7) sitting with one's legs folded sideways, (8) sitting with the lower legs extended behind at 45 degree angles and (9) always using the same shoulder for a shoulder bag. The items regarding signs of pelvic distortion included (1) lengths of the right and left legs being different when the legs are extended, (2) shoe sole abrasion being different for right and left shoes, (3) heights of left and right shoulders being different, (4) heights of left hip and right hip being different, (5) right and left knees being separated when holding the knees in the sitting position, (6) heights of right and left knees being different when holding the knees in a sitting position, (7) angles of right and left toes being different in the recumbent position, (8) lengths of the hem on the right and left sides being different, (9) heights of the fingers of right and left hands being different when the upper limbs are raised and (10) heights of the right and left knees being different when sitting on the floor with the feet making full contact with the floor. Each item regarding the positions and signs of pelvic distortion was assessed by the woman herself according to its presence.

### Measurements of pelvic shape

We measured the angle of pelvic inclination and the distance between right and left anterior superior iliac spines by using POSTURE ANALYSER (PA200, THE BIG SPORTS Co., Ltd., Osaka, Japan). The angle of pelvic inclination was defined as the angle made by a line connecting the anterior superior iliac spine to the anterior posterior iliac spine and a horizontal line. Photographs of the subjects on a platform that were taken with a digital camera were inputted into a computer and were analyzed by using PA200 application software. The subjects wore thin clothes on the upper half of the body and leggings on the lower half of the body. Color seals as markers were put on right and left tuberosities of the fifth metatarsal bones, right and left anterior superior iliac spines, and anterior posterior iliac spines. The subjects stood with a posture in which there was a fist-sized gap between the legs and points of the right and left tuberosities of the fifth metatarsal bones were matched on the platform line. With this standing position, the subjects looked straight ahead with the upper limbs relaxed. Each subject made four 90-degree rotations while keeping the points of right and left tuberosities of the fifth metatarsal bones on the platform lines, and photographs were taken at each rotation from longitudinal and lateral directions. All of the photographs were taken by the same person in a room where privacy was protected and was equipped with air conditioning for thin clothes. For the validation study, right and left angles of inclination and the distance between right and left anterior superior iliac spines in 2 young women were measured 5 times repeatedly. In addition, the angles and distances were measured by using pelvimetry and a goniometer, and these values were compared to those obtained by using posture analyzer.

### Date analysis

We divided the subjects into three groups according to tertiles of angle of pelvic inclination and distance between right and left anterior superior iliac spines. Differences in background characteristics, menstruation-related factors, physical symptoms, positions of pelvic distortion and signs of pelvic distortion among the three groups were evaluated by the Kruskal-Wallis rank test and  $\chi^2$  test. Correlations of angle of pelvic inclination with distance between right and left anterior superior iliac spines were determined by using Spearman's rank order correlation analyses. Multiple regression analysis by stepwise methods was used for estimation of predictive factors of pelvic shape. All p values are two-tailed, and those less than 0.05 were considered to be statistically significant. Statistical analyses for data evaluation were carried out using SPSS version 22 for Windows (IBM Corp., Armonk, NY).

### Ethics

The Ethics Committee of Kagawa Prefectural University of Health Sciences approved the study (number 98).

### Results

#### Validation study for PA 200

As can be seen in Table 1, right and left angles of pelvic inclination determined by PA 200 were 0.30-0.32 radian and those determined by a goniometer were 0.26-0.34 radian. The distances between right and left anterior superior iliac spines determined by PA 200 were 231.28-248.59 mm and those determined by pelvimetry were 240-250 mm. The coefficients of variation (CVs) in right and left angles of pelvic inclination were 3.7-5.7%, and CVs in the distance between right and left anterior superior iliac spines were 0.87-1.61% (Table 1).

#### Background characteristics

Mean age (standard deviation [SD]) of the subjects was 20.2 (1.1) (ranging from 19 to 28) years. Mean values (SD) of height, weight and BMI were 157.1 (4.8) cm, 50.6 (5.5) kg and 20.5 (2.0), respectively (Table 2). According to the BMI classification, proportions of lean, normal and overweight subjects were 17.4%, 79.3% and 3.3%, respectively. The proportion of subjects with a menstrual cycle between 25 and 38 days was 82.6%, and the proportion of subjects with menstrual duration between 3 and 7 days was 95.7%. The proportion of subjects with menstrual pain was 79.3%.

The proportions of subjects with physical symptoms of headache, lumbar pain, shoulder stiffness and sensitivity to cold were 27.2%, 32.6%, 60.9% and 70.7%, respectively. As can be seen in Table 3, shoulder stiffness was significantly associated with low body weight ( $p=0.042$ ) according to tertiles of body weight. Associations of headache, lumbar pain and sensitivity to cold with body height and BMI were not found.

As can be seen in Table 4, items that large percentages of women responded to for position of pelvic distortion were use of the same shoulder for a shoulder bag (82.6%), rounded shoulder (78.3%) and habit of crossing the legs (77.2%). Items that large percentages of women responded to for signs of pelvic distortion were "Heights of right and left shoulders being different (52.2%)" and "Shoe sole abrasion being different for right and left shoes (51.1%)".

The mean (SD) angles of inclination in the right pelvis and left pelvis were 0.31 (0.09) radian and 0.31(0.09) radian, respectively, and these angles showed a significant positive correlation ( $r=0.832$ ,  $p<0.001$ ). The proportions of subjects with right and left angles of

**Table 1:** Coefficients of variations of pelvic inclination and distance between right and left anterior superior iliac spines in two women.

	A				B			
	Mean	Standard deviation	CV (%)	Values determined by a goniometer and pelvimetry	Mean	Standard deviation	CV (%)	Values determined by a goniometer and pelvimetry
Right angle of pelvic inclination (radian)	0.30	0.01	3.80	0.31	0.33	0.02	5.20	0.26
Left angle of pelvic inclination (radian)	0.31	0.01	3.70	0.35	0.31	0.02	5.70	0.26
Distance between right and left anterior superior iliac spines (mm)	231.30	2.00	0.90	240.00	248.60	4.00	1.60	250.00

**Note:** CV: Coefficient of variation

**Table 2:** Baseline characteristics of the subjects.

		Mean	SD
Age (years)		20.2	1.1
Height (cm)		157.1	4.8
Weight (kg)		50.6	5.5
BMI (kg/m <sup>2</sup> )		20.5	2.0
Age of menarche (years)		12.2	1.4
Menstrual cycle (days)	≤ 24	6 ( 6.5)	
	25-38	76 (82.6)	
	≥ 39	10 (10.9)	
Duration of menstruation (days)	≤ 2	1 ( 1.1)	
	3-7	88 (95.7)	
	≥ 8	3 ( 3.2)	
Presence of menstrual pain	yes	73 (79.3)	
	no	19 (20.7)	
Presence of physical symptoms			
Headache	yes	25 (27.2)	
	no	67 (72.8)	
Lumbar pain	yes	30 (32.6)	
	no	62 (67.4)	
Shoulder stiffness	yes	56 (60.9)	
	no	36 (39.1)	
Sensitivity to cold	yes	65 (70.7)	
	no	27 (29.3)	

**Note:** SD: Standard deviation, Proportions (%) are indicated in parenthesis

**Table 3:** Comparison of physical symptoms and menstrual pain according to tertiles of body Weight.

		Low (n=32)		Medium (n=30)		High (n=30)		p value
		Mean	SD	Mean	SD	Mean	SD	
Body weight (kg)		45.1	2.4	50.1	1.4	57.0	3.6	<0.001
Presence of menstrual pain	yes	27		21		25		0.304
	no	5		9		5		
Presence of physical symptoms								
Headache	yes	9		8		8		0.989
	no	23		22		22		
Lumbar pain	yes	11		9		10		0.930
	no	21		21		20		
Shoulder stiffness	yes	14		20		22		0.042
	no	18		10		8		
Sensitivity to cold	yes	26		20		19		0.254
	no	6		10		11		

**Note:** Body weight was indicated as mean and standard deviation

inclination more than 0.17 radian, were 91.3% and 92.4%, respectively. The mean value (SD) of right and left angles of inclination was 0.31 (0.08) radian. The mean distance (SD) between right and left

anterior superior iliac spines was 270.1(23.4) mm. The mean angle of inclination was positively correlated with the mean distance between right and left anterior superior iliac spines (r=0.256, p=0.014).

**Table 4:** Proportions of positions and signs of pelvic distortion.

	Items		Number	Proportion (%)
Position	Unhealed past injury in lower legs	yes	6	6.5
		no	86	93.5
	Bowlegs from childhood	yes	14	15.2
		no	78	84.8
	Flat feet	yes	11	12.0
		no	81	88.0
	Rounded shoulders	yes	72	78.3
		no	20	21.7
	Weak muscles in the abdomen and back	yes	61	66.3
		no	31	33.7
	Habit of crossing the legs	yes	71	77.2
		no	21	22.8
	Sitting with one's legs folded sideways	yes	55	59.8
		no	37	40.2
Sitting with the lower legs extended behind at 45 degree angles	yes	30	32.6	
	no	62	67.4	
Always using the same shoulder for a shoulder bag	yes	76	82.6	
	no	16	17.4	
Sign	Lengths of the right and left legs being different when the legs are extended	yes	24	26.1
		no	68	73.9
	Shoe sole abrasions being different for right and left shoes	yes	47	51.1
		no	45	48.9
	Heights of right and left shoulders being different	yes	48	52.2
		no	44	47.8
	Heights of right hip and left hip being different	yes	26	28.3
		no	66	71.7
	Right and left knees being separated when holding the knees in the sitting position	yes	22	23.9
		no	70	76.1
	Heights of right and left knees being different when holding the knees in a sitting position	yes	14	15.2
		no	78	84.8
	Angles of right and left toes being different in the recumbent position	yes	27	29.3
		no	65	70.7
	Lengths of the hem on the right and left sides being different	yes	42	45.7
		no	50	54.3
	Heights of the fingers of right and left hands being different when the upper limbs are raised	yes	17	18.5
		no	75	81.5
Heights of the right and left knees being different when sitting on the floor with the feet making full contact with the floor	yes	21	22.8	
	no	71	77.2	

### Associations of values of pelvic shape with various factors

The distance between right and left anterior superior iliac spines showed significant positive associations with body weight ( $r=0.424$ ,  $p<0.001$ ), body height ( $r=0.254$ ,  $p = 0.015$ ) and BMI ( $r=0.256$ ,  $p=0.014$ ). In addition, the distance was negatively associated with age ( $r=-0.246$ ,  $p=0.018$ ). However, the angles of pelvic inclination were not significantly correlated with body weight, body height, BMI and age.

Analyses for tertiles of angle of inclination and distance between right and left anterior superior iliac spines

We divided various factors into three groups according to tertiles of angle of inclination. There were no significant differences in age, height, weight, BMI, age at menarche and physical symptoms (Table 5). As can be seen in Table 6, a large percentage of subjects with a wide angle of inclination responded positively to the item "Heights of the fingers of the right and left hands being different when the upper limbs are raised" ( $p=0.030$ ). According to the tertiles of distance between right and left anterior superior iliac spines, subjects with a large distance had significantly larger height ( $p=0.040$ ) and larger

body weight ( $p=0.001$ ) (Table 7). Subjects with a large distance showed a tendency for sensitivity to cold ( $p=0.055$ ). Also, a large percentage of subjects with a large distance responded positively to the item "Unhealed past injury in lower legs" ( $p=0.002$ ) and the item "Sitting with one's legs folded sideways" ( $p=0.018$ ) (Table 8).

### Predictive factors for pelvic shape

We extracted predictive factors for pelvic shape. The predictive factor for pelvic angle of inclination was estimated to be the distance between right and left anterior superior iliac spines ( $R^2=0.075$ ,  $F=8.37$ ,  $p<0.05$ ). The predictive factors for distance between right and left anterior superior iliac spines were estimated to be body weight, pelvic angle of inclination, body height, the item "Heights of the fingers of the right and left hands being different when the upper limbs are raised" and lumbar pain ( $R^2=0.408$ ,  $F=13.51$ ,  $p<0.001$ ).

### Discussion

By using POSTURE ANALYSER (PA200), which has been newly developed, we assessed pelvic shape and examined associations of

**Table 5:** Comparison of factors according to tertiles of angle of pelvic inclination.

		Low(n=30)		Medium(n=32)		High(n=30)		p value
		Mean	SD	Mean	SD	Mean	SD	
Angle of pelvic inclination (radian)		0.22	0.05	0.32	0.01	0.41	0.05	<0.001
Age (years)		20.10	0.60	20.30	1.60	20.10	0.80	0.987
Height (cm)		157.90	5.10	156.90	3.50	156.40	5.50	0.607
Weight (kg)		50.30	5.40	51.80	5.20	49.80	6.00	0.385
BMI (kg/m <sup>2</sup> )		20.30	1.80	20.80	1.70	20.30	2.30	0.328
Age of menarche (years)		12.50	1.30	12.20	1.50	12.10	1.50	0.270
Physical symptoms								
Headache	yes	8		7		10		0.597
	no	22		25		20		
Lumbar pain	yes	10		9		11		0.769
	no	20		23		19		
Shoulder stiffness	yes	19		17		20		0.521
	no	11		15		10		
Sensitivity to cold	yes	23		22		20		0.667
	no	7		10		10		

**Note:** SD: Mean and standard deviation

**Table 6:** Proportions of positions and signs of angle of pelvic inclination.

as	Items		Low	Medium	High	p value
			(n=30)	(n=32)	(n=30)	
Position	Unhealed past injury in lower legs	yes	1	1	4	0.184
		no	29	31	26	
	Bowlegs from childhood	yes	3	6	5	0.609
		no	27	26	25	
	Flat feet	yes	3	5	3	0.731
		no	27	27	27	
	Rounded shoulder	yes	22	25	25	0.643
		no	8	7	5	
	Weak muscles in the abdomen and back	yes	22	20	19	0.610
		no	8	12	11	
	Habit of crossing the legs	yes	23	23	25	0.560
		no	7	9	5	
	Sitting with one's legs folded sideways	yes	20	18	17	0.645
		no	10	14	13	
Sitting with the lower legs extended behind at 45 degree angles	yes	9	11	10	0.930	
	no	21	21	20		
Always using the same shoulder for a shoulder bag	yes	24	27	25	0.895	
	no	6	5	5		
Sign	Lengths of the right and left legs being different when the legs are extended	yes	5	11	8	0.283
		no	25	21	22	
	Shoe sole abrasions being different for right and left shoes	yes	16	12	19	0.121
		no	14	20	11	
	Heights of right and left shoulders being different	yes	18	18	12	0.255
		no	12	14	18	
	Heights of right hip and left hip being different	yes	8	7	11	0.422
		no	22	25	19	
	Right and left knees being separated when holding the knees in the sitting position	yes	9	8	5	0.473
		no	21	24	25	
	Heights of right and left knees being different when holding the knees in a sitting position	yes	5	6	3	0.609
		no	25	26	27	
	Angles of right and left toes being different in the recumbent position	yes	9	7	11	0.440
		no	21	25	19	
	Lengths of the hem on the right and left sides being different	yes	12	11	19	0.055
		no	18	21	11	
	Heights of the fingers of right and left hands being different when the upper limbs are raised	yes	1	8	8	0.033
		no	29	24	22	
Heights of the right and left knees being different when sitting on the floor with the feet making full contact with the floor	yes	8	5	8	0.486	
	no	22	27	22		

**Table 7:** Comparison of factors according to tertiles of the distance between right and left anterior superior iliac spines.

	Low(n=27)		Medium(n=34)		High(n=31)		p-value
	Mean	SD	Mean	SD	Mean	SD	
Distance between right and left anterior superior iliac spines (mm)	246.0	15.0	269.1	4.7	294.6	16.5	<0.001
Age (years)	20.3	1.6	20.0	0.7	20.2	0.9	0.631
Height (cm)	155.0	3.9	157.3	4.1	158.7	5.5	0.040
Weight (kg)	48.1	4.6	49.7	4.4	53.8	6.0	0.001
BMI (kg/m <sup>2</sup> )	20.0	1.8	20.1	1.5	21.3	2.3	0.054
Age of menarche (years)	12.3	1.4	12.3	1.3	12.0	1.5	0.762
Physical symptoms							
Headache	yes	6	9	10			0.688
	no	21	25	21			
Lumbar pain	yes	5	15	10			0.106
	no	22	19	21			
Shoulder stiffness	yes	15	22	19			0.766
	no	12	12	12			
Sensitivity to cold	yes	20	24	21			0.055
	no	7	10	10			

**Table 8:** Proportions of positions and signs of the distance between right and left anterior superior iliac spines.

	Items		Low	Medium	High	P-value
			(n=27)	(n=34)	(n=31)	
Position	Unhealed past injury in lower legs	yes	0	0	6	0.002
		no	27	34	25	
	Bowlegs from childhood	yes	2	6	6	0.398
		no	25	28	25	
	Flat feet	yes	4	5	2	0.510
		no	23	29	29	
	Rounded shoulder	yes	19	26	27	0.290
		no	8	8	4	
	Weak muscles in the abdomen and back	yes	21	22	18	0.276
		no	6	12	13	
Habit of crossing the legs	yes	22	25	24	0.763	
	no	5	9	7		
Sitting with one's legs folded sideways	yes	11	26	18	0.018	
	no	16	8	13		
Sitting with the lower legs extended behind at 45 degree angles	yes	8	14	8	0.387	
	no	19	20	23		
Always using the same shoulder for a shoulder bag	yes	20	29	27	0.373	
	no	7	5	4		
Sign	Lengths of the right and left legs being different when the legs are extended	yes	5	7	12	0.142
		no	22	27	19	
	Shoe sole abrasions being different for right and left shoes	yes	14	16	17	0.818
		no	13	18	14	
	Heights of right and left shoulders being different	yes	17	17	14	0.380
		no	10	17	17	
	Heights of right hip and left hip being different	yes	5	6	12	0.225
		no	22	25	19	
	Right and left knees being separated when holding the knees in the sitting position	yes	3	8	11	0.095
		no	24	26	20	
	Heights of right and left knees being different when holding the knees in a sitting position	yes	5	3	6	0.424
		no	22	31	25	
	Angles of right and left toes being different in the recumbent position	yes	8	7	12	0.277
		no	19	27	19	
	Lengths of the hem on the right and left sides being different	yes	10	15	17	0.388
		no	17	19	14	
	Heights of the fingers of right and left hands being different when the upper limbs are raised	yes	3	6	8	0.351
		no	24	28	23	
	Heights of the right and left knees being different when sitting on the floor with the feet making full contact with the floor	yes	6	7	8	0.879
no		21	27	23		

measurements with physical symptoms related to distortion of the pelvis and menstruation-related factors in young Japanese women. In the validation study, angles of pelvic inclination and distances between right and left anterior superior iliac spines determined by using POSTURE ANALYSER were similar to those determined by using a goniometer and those determined by pelvimetry. Thus, the measurement by using POSTURE ANALYSER was validated. Images acquired by this system can be analyzed by using a computer after measurements have been made. In addition, values after the decimal point, which cannot be evaluated by pelvimetry or a goniometer, can be obtained. Therefore, measurement of the pelvic cavity by POSTURE ANALYSER is useful. Further analyses for studies of physical alignment can also be performed.

We showed that the mean angle of pelvic inclination in young Japanese women was 0.31 radian. To date, there have been few reports regarding angle of pelvic inclination in Japanese young women. Pelvic inclination in young women determined by using a University of Tokyo type goniometer was 0.30 (SD 0.05) radian [12]. The values obtained by using POSTURE ANALYSER were similar to the values measured by using a University of Tokyo type goniometer. It has been shown that the posture becomes inclined backward with advance of age [13]. Chad [14] suggested that more than 10 degrees be determined as forward-bent posture and less than 8 degrees be determined as backward tilting by using pelvimetry. Based on this evaluation, the proportion of women with forward-bent posture is approximately 90%, suggesting that many of the young Japanese women in the present study have forward-bent posture. Forward-bent posture is recognized as a risk factor for low back pain [15]. In the present study, the percentage of subjects with low back pain was not high. The reason for the discrepancy in the proportion of subjects with forward-bent posture and the proportion of subjects with low back pain is not clear.

We showed that the mean distance between right and left anterior superior iliac spines was 270.1 mm. It has been reported that the mean distance and range of distances between right and left anterior superior iliac spines were 249.3 and 200-300 mm, respectively, in parturient women whose mean height and mean BMI were 166 cm and 22.6, respectively, during the period from 1985 to 2009 [4]. It has been reported that the mean distance between right and left anterior superior iliac spines was 218.5 mm in Japanese women [16]. Thus, the distances between right and left anterior superior iliac spines in the present study are larger than those in the previous study. It has been reported that large body height was associated with a wide pelvic cavity [2,17] and that distance between right and left anterior superior iliac spines had weak correlations with height, weight and BMI [4]. We also showed that large body weight and large height are factors suggesting a large distance between right and left anterior superior iliac spines. It is thought that women with a large physique have a large distance between right and left anterior superior iliac spines and a wide pelvic cavity. The change in the distance between right and left anterior superior iliac spines may be involved in the change in physique in young women in Japan.

Lim [6] reported that subjects with low back pain had a greater pelvic angle of inclination than did those with healthy backs. We showed that lumbago was a factor suggesting a large distance between right and left anterior superior iliac spines but not large pelvic angle of inclination. Also, we found that the item "Heights of the fingers of the right and left hands being different when the upper limbs are raised" suggested a large pelvic angle of inclination and a large

distance between right and left anterior superior iliac spines. It is easy to self-check whether there is a difference in the heights of the fingers of right and left hands being different when the upper limbs are raised. Since a large distance between right and left anterior superior iliac spines or a large pelvic angle of inclination might cause lumbar pain, self-checking may be useful for prevention of lumbago. By using self-checking, doing exercise for increasing muscular strength around the pelvic cavity might be possible in an early stage.

In the present study, an association of pelvic shape with menstruation-related factors was not found. The reason may be the large proportion of subjects with regular menstruation. Sugiyama [18] reported that the angle of pelvic inclination was not significantly correlated with presence of menstrual pain in university students. It has been reported that young women with amenorrhea had low body weight and low BMI compared to young women with regular menstruation. In the present study, we confirmed associations of pelvic shape with body weight and height. Further study regarding the association of pelvic shape with menstrual disorders may be needed.

This study has several limitations. Since the subjects were recruited from one university, the results may not reflect results for all young Japanese women. The number of the subjects was also small. Further study on the association of pelvic shape with menstrual problems is needed.

In conclusion, by using a newly developed posture analyzer, increases in body weight and height were shown to be associated with pelvic shape in young Japanese women. In addition, the change in pelvic size may be estimated by the item "Heights of the fingers of the right and left hands being different when the upper limbs are raised".

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