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Original Article

Age-related Changes in Maximum Pelvic Anteversion and Retroversion Angles Measured in the Sitting Position

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Abstract. [Purpose] The purpose of this study was to investigate the relationship between age and the maximum pelvic anteversion and retroversion angles, as well as the associated pelvic range of motion, measured in a sitting position with free knee movement. [Subjects] A total of 132 healthy volunteers (74 women, 58 men; age range, 20–79 years) were divided into six groups based on age (20–29, 30–39, 40–49, 50–59, 60–69, and 70–79 years). [Methods] The maximum pelvic anteversion and retroversion angles were measured manually five times by a goniometer in a sitting position that allowed free movement of the knee joints. [Results] There was a significant effect of age group on the maximum pelvic anteversion and retroversion angles and pelvic range of motion (the difference between these angles). There was a significant correlation between age and the maximum pelvic anteversion angle, maximum pelvic retroversion angle, and pelvic range of motion. [Conclusion] The maximum pelvic anteversion and retroversion angles and pelvic range of motion were significantly correlated with age. The maximum pelvic anteversion angle and pelvic range of motion were most affected by age.
Key words: Aging, Mobility limitation, Pelvis

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INTRODUCTION

Numerous researchers have investigated the relationship between movements of the lumbar spine and the pelvis[1, 2)]. The relationship between the pelvic inclination angle and lumbar spine lordosis is more distinct in the sitting position than in the standing position[1, 3)]. Therefore, lumbar spine (kyphosis and lordosis) mobility may be reflected in seated pelvic mobility (inclination).

Because the pelvis moves forward and backward around the hip joint as a pivotal axis in the seated position, pelvic tilt in the sagittal plane may be affected by flexion and extension mobility of the hip joints. Since the hamstring muscles originate at the ischial tuberosity of the pelvis, the tension in the hamstring muscles has an effect on pelvic posture[4, 5)]. Thus, a forward pelvic tilt may increase tension in the hamstring muscles when sitting with a fixed knee angle and the plantar aspect of the foot in contact with the floor. Muyor et al.[6)] reported that the forward pelvic tilt angle increased after hamstring muscle stretching, and Feland et al.[7)] confirmed that pelvic mobility in the sagittal plane increased after hamstring muscle stretching in elderly people. The increase in tension in the hamstring muscles when sitting with the soles of the feet in contact with the floor may restrict pelvic forward tilt. Therefore, free movement of the knees should be possible during pelvic movement when sagittal plane pelvic mobility is investigated in the sitting position. However, some seated pelvic mobility studies have not clearly described foot contact with the floor or the knee joint positioning[2, 8)].

In general, joint mobility reduces with advancing age[9, 10)]. Connective tissue compliance is considered a major factor in musculoskeletal flexibility[7)]. Lumbar spine mobility in both lordosis and kyphosis decreases with advancing age[1, 11, 12)]. Keorochana et al.[13)] suggested that the degeneration of the interspinous ligaments with aging is one of the factors contributing to low mobility of the lumbar spine.

The purpose of this study was to investigate the relationship between age and maximum pelvic anteversion and retroversion angles, as well as the associated pelvic range of motion, measured in a sitting position with free knee movement. Pelvic range of motion was defined as the difference between the maximum pelvic anteversion and retroversion angles. Due to the close relationship between lumbar spine integrity and mobility and pelvic tilt, we hypothesized that pelvic range of motion would be affected by aging.

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Table 1. Mean and standard deviation of the pelvic angles in each age group

Age group	n	Maximum pelvic anteversion angle (º)	Maximum pelvic retroversion angle (º)	Pelvic range of motion (º)
20–29 years	n=48	84.5±3.4	123.1±6.1	38.7±6.0
30–39 years	n=13	87.8±4.1	125.7±6.8	37.6±9.2
40–49 years	n=13	90.1±5.4 [a]	124.1±8.9	34.0±8.7
50–59 years	n=23	88.8±4.6 [a]	118.2±9.8	29.4±8.4 [a,b]
60–69 years	n=19	92.6±6.5 [a,b]	117.1±8.7 [b]	24.3±6.3 [a,b,c]
70–79 years	n=16	93.9±4.0 [a,b,d]	117.8±9.3	23.8±8.6 [a,b,c]

[a]Significant difference from 20–29 years. [b]Significant difference from 30–39 years. [c]Significant difference from 40–49 years. [d]Significant difference from 50–59 years.

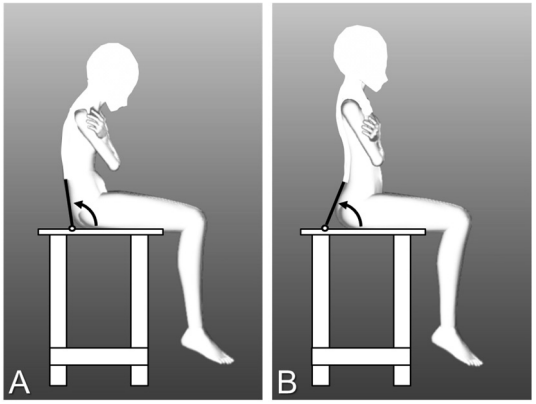

Fig. 1. Schema for measuring the pelvic inclination angle: (A) pelvic retroversion angle, (B) pelvic anteversion angle

SUBJECTS AND METHODS

The participants were 132 healthy volunteers (74 females, 58 males) between the ages of 20 to 79 (Table 1). The participants were recruited from a university, two workplaces, and the community near the university after the purpose and contents of the study had been explained. Participants were free from neurological and orthopedic impairments. All participants gave informed consent to the experimental protocol, which was approved by the institutional ethics committee of Kanazawa University in accordance with the Declaration of Helsinki (No. 422).

All measurements were taken with the participants seated on a chair with a 50 × 50 cm seat face that was 3 cm thick. The height of the seat surface was 65 cm from the floor to allow free movement of the knee joints. The participants sat down on the chair, aligning the front edge of the seat face with the point 66% along the length of the thigh from the greater trochanter.

In this study, pelvic angles were evaluated by a simple method for measuring the sacral inclination angle[14]. A manual goniometer attached to an inclinometer with a resolution of one degree was used to measure pelvic angles. The stationary and moving axes of this goniometer were defined as the anteroposterior axis on the seating face and the longitudinal axis through the midline of the dorsal sacral surface, respectively (Fig. 1). Therefore, the pelvic tilt angle was defined as the angle between the longitudinal axis through the midline of the dorsal sacral surface and the anterior horizontal line (Fig. 1).

Subjects were instructed to maintain the same shoulder anteroposterior position throughout the movements of pelvic inclination to avoid trunk anteroposterior movement. The instruction to subjects was "Please maintain your shoulder position during pelvic movement". After maintaining a quiet sitting position for 20 seconds, participants performed alternating maximum pelvic anteversion and retroversion positions five times. The maximum and minimum angles were excluded, and the mean of the three remaining values was calculated. The pelvic range of motion was defined as the difference between the maximum pelvic anteversion and retroversion angles.

One-way ANOVA was used to assess the effect of age group on maximum pelvic anteversion angle, maximum pelvic retroversion angle, and the pelvic range of motion. Post hoc multiple comparison analysis using Tukey's honestly significant difference test was used to assess significant differences found by ANOVA. Pearson correlations were used to assess the relationships between age and the following parameters: maximum pelvic anteversion angle, maximum pelvic retroversion angle, and pelvic range of motion. All statistical analyses were performed using SPSS 19.0 J (SPSS Japan, Tokyo, Japan). The alpha level was set at < 0.05.

RESULTS

There was a significant effect of age group on the maximum pelvic anteversion angle ($F_{5, 126}$=15.8, p<0.001; Table 1). The maximum pelvic anteversion angles in participants aged 40–49, 50–59, 60–69, and 70–79 years were significantly smaller than in participants aged 20–29 years (p<0.01, <0.01, <0.001, and <0.001, respectively; Table 1). The maximum pelvic anteversion angles in participants aged 60–69 and 70–79 years were significantly smaller than in participants aged 30–39 years (p<0.05 for both), and the maximum pelvic anteversion angle was significantly smaller in participants aged 70–79 than in participants aged 50–59 years (p<0.01; Table 1). There was a significant correlation between age and the maximum pelvic anteversion angle (r=0.61, p<0.001; Fig. 2).

There was a significant effect of age group on the maximum pelvic retroversion angle ($F_{5, 126}$=4.0, p<0.05; Table 1). However, after multiple post hoc comparisons, there were no age groups that showed significant differences compared with participants aged 20–29 years. The maximum pelvic retroversion angle was significantly smaller in participants aged 60–69 than in participants aged 30–39 years (p<0.05; Table 1). There was a significant correlation between age and the maximum pelvic retroversion angle (r=-0.29, p<0.05; Fig. 2).

There was a significant effect of age group on pelvic range of motion ($F_{5, 126}$=18.7, p<0.001; Table 1). The pelvic

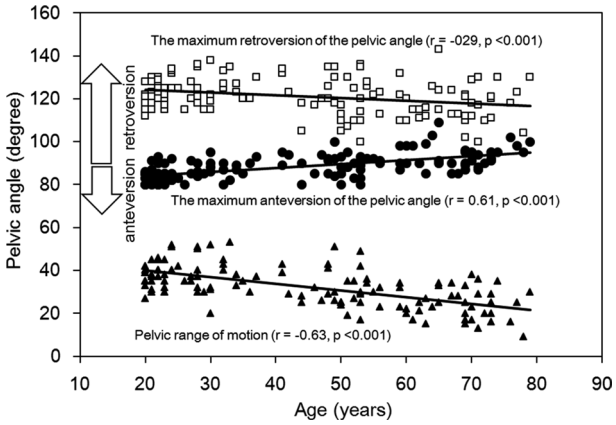

Fig. 2. Correlations between age and maximum pelvic anteversion angle (black circles), maximum pelvic retroversion angle (white squares), and pelvic range of motion (black triangles)

ranges of motion were significantly smaller in participants aged 50–59, 60–69, and 70–79 years than in participants aged 20–29 ($p<0.001$ for all) and those aged 30–39 years ($p<0.05$, <0.001, and <0.001, respectively; Table 1), and the pelvic ranges of motion were significantly smaller in participants aged 60–69 and 70–79 years than in participants aged 40–49 years ($p<0.01$ for both; Table 1). There was a significant correlation between age and the range of pelvic motion ($r=-0.63$, $p<0.001$; Fig. 2).

DISCUSSION

In the present study, pelvic angles were evaluated by a simplified measuring method for the sacral inclination angle[14]. The maximum pelvic anteversion angle, maximum pelvic retroversion angle, and range of pelvic motion were significantly affected by aging. The relationships between these variables and age were approximated using linear regression equations. These results indicate that pelvic mobility in the sitting position is affected by aging.

Hamstring tension probably had an insignificant effect on pelvic mobility in this study, especially on anterior tilt, because the knees had free mobility during pelvic movement. The hip flexion angle during maximum pelvic anteversion was 95° in participants aged 20–29 years and 87° in participants aged 70–79 years. The hip flexion angle during maximum pelvic retroversion was 57° in participants aged 20–29 years and 63° in participants aged 70–79 years. The passive hip joint flexion and extension angles in the elderly were approximately 120° and 17°, respectively[9]. Therefore, pelvic mobility in the present study did not seem to be affected by hamstring muscle tension or hip joint mobility. The pelvic mobility measured in this study fairly reflected the lumbar spine mobility based on previously reported strong correlations between pelvic tilt or sacral tilt angle and the lumbar spine lordosis angle in the sitting position[1, 14, 15]. In addition, pelvic mobility is larger in the sitting position than in the standing position[2]. Therefore, changes in the maximum pelvic anteversion and retroversion angles with aging might be directly affected by the changes in lumbar spine mobility that occur with aging[12]. However, due to aging-related shortening of the hamstring muscles, the maximum pelvic anteversion angle may be more restricted when performing this movement without free mobility at the knee.

The pelvic range of movement was about 40° in participants aged 20–29 years, while it was 24° in participants aged 60–69 and 70–79 years. The rate of pelvic mobility limitation with aging in this study (about 30%) is larger than that previously reported for hip extension (20%), which is considered the most limited joint in the lower extremities[9]. Therefore, sagittal plane pelvic mobility may be an important factor related to mobility limitation for sit-to-stand movement in elderly adults.

A manual goniometer attached to an inclinometer with a resolution of one degree was used in the present study. Therefore, the reliability of manual goniometer measurement was probably guaranteed by the inclinometer[16]. However, the test-retest reliability should be evaluated.

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