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Pelvic Movement in Aging Individuals and Stroke

Patients

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Additional information is available at the end of the chapter

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Abstract

The mobility of the lumbar spine (anteversion and retroversion) may be reflected in seated pelvic mobility. When sitting with the soles of the feet in contact with the floor, friction may restrict the flexion of the knees and, consequently, the pelvic anteversion. In general, joint mobility declines with advancing age. Lumbar spine mobility in anteversion and retroversion also decreases with advancing age. The first half of this chapter is based on a study that investigated the relationship between age and the maximum pelvic anteversion and the retroversion angles in healthy volunteers. The measurements were performed with the subject in a sitting position with free knee movement. On the other hand, the sit-to-stand movement is one of the most mechanically demanding tasks undertaken during daily activity. The sacral sitting posture, which is a characteristic posture of stroke patients, is not ideal for smoothly executing the sit-to-stand movement. Stroke patients may adopt this posture due to the need to increase sitting stability. The second half of this chapter discusses a study that investigated the relationship between the pelvic anteversion and retroversion angles and the ability of stroke patients to perform the sit-to-stand movement.

Keywords: pelvic movement, anteversion, retroversion, aging, stroke, sit-to-stand

1. Introduction

Maintaining sagittal balance is important to both sitting and standing. Sagittal balance, or “neutral upright sagittal spinal alignment,” is a postural goal of surgical, ergonomic, and physiotherapeutic intervention [1]. Kyphotic curvature of the spine negatively impacts the quality of life (QOL) in elderly people [2]. Kasukawa et al. reported that the sagittal balance was well maintained in subjects who had both a good thoracic range of motion (ROM) and

good lumbar ROM and back muscle strength, which indicates that these factors are also related in maintaining sagittal balance [2]. The clarification of the relationship between the QOL and abnormal posture in elderly individuals may help to improve the QOL through preventive methods and exercises [3]. Although the degree of lumbar lordosis when sitting has been shown to be weakly associated with age, lumbar lordosis was not found to be affected by lifestyle, the level of physical activity, or an individual's type of work [4]. Little is known about the sitting posture of elderly individuals in comparison with young individuals [5]; thus, investigating the effects of aging on the sagittal spinal and pelvic alignment in the sitting position is important for clarifying the relationship between pelvic movement and the QOL. Sitting positions are generally categorized into two types: the quiet sitting position and the functional sitting position. A person sits in the functional sitting position during (or when anticipating) physical activity. The functional sitting position therefore requires control in various sitting postures.

Multiple movements of the spine and pelvis are needed to maintain the various sitting positions. The relationship between the movements of the lumbar spine and pelvis has been investigated [5, 6]. The relationship between the pelvic inclination angle and lumbar spine lordosis was more distinct in the sitting position than in the standing position [5, 7]. Thus, lumbar spine mobility (kyphosis and lordosis) may be reflected in seated pelvic mobility. However, it has been reported that joint mobility is generally reduced by aging. The trunk mobility of elderly individuals is inferior to that of young people [8–10]. In particular, lumbar spine mobility in both lordosis and kyphosis decreases with aging [1, 11, 12]. In addition, Keorochana et al. suggested that the degeneration of the interspinous ligaments with aging is one of the factors that contributes to the low mobility of the lumbar spine [13]. Hence, the movement patterns of elderly individuals may be restricted when they are seated because there is less variety in their sitting positions in comparison with young subjects.

The pelvic tilt in the sagittal plane may be affected by flexion and the extension mobility of the hip joints, because the pelvis moves forward and backward around the hip joint as a pivotal axis in the seated position. Since the hamstring muscles originate at the ischial tuberosity of the pelvis, the tension in the hamstring muscles has an effect on the pelvic inclination angle in the sitting position [14, 15]. Thus, a forward pelvic tilt may increase the tension in the hamstring muscles when sitting with a fixed knee angle and the sole of the foot in contact with the floor. Connective tissue compliance is considered a major factor in musculoskeletal flexibility [16]. Muyor et al. [17] reported that the forward pelvic tilt angle increased after hamstring muscle stretching, and Feland et al. [16] confirmed that pelvic mobility in the sagittal plane increased in elderly people after hamstring muscle stretching. The increase in the tension in the hamstring muscles when sitting with the soles of the feet in contact with the floor may restrict the pelvic forward tilt. Thus, the free movement of the knees should be possible during pelvic movement when sagittal plane pelvic mobility is investigated with a subject in a sitting position. However, some sitting pelvic mobility studies have not clearly described foot contact with the floor or the knee joint positioning [6, 18].

On the other hand, the recovery of sitting balance is commonly assumed to be essential for obtaining independence in other vital functions such as reaching, sit-to-stand, and sitting

down [19–21]. The early assessment and management of trunk control should be emphasized after stroke [22]. Many researchers have suggested that the trunk control or sitting balance of early stage stroke patients can predict a late stage activities of daily living (ADL) outcome [19, 22, 23]. The sit-to-stand task is frequently performed and this ability is considered a prerequisite for upright mobility and therefore, for performing other important daily activities such as locomotion [24, 25]. Riley et al. suggested that the sit-to-stand movement is the most mechanically demanding task undertaken during daily activity [26]. The sit-to-stand movement represents a common functional movement that is practiced in the early stage of rehabilitation [27].

Stroke patients have less stability in the sitting position in comparison with age-matched healthy subjects [28–30]. The reason for this is explained in a number of reports. In stroke patients, the activity of the rectus abdominis and latissimus dorsi muscles on the affected side of the body is reduced and delayed in comparison to both the unaffected side and control subjects [31]. Moreover, the temporal synchronization between the pertinent muscular pairs in stroke patients is lower in comparison to healthy subjects [32]. The following factors can also be considered to be related to the sitting position: firstly, stroke patients cannot adequately flex the hip when the trunk extensor muscles are contracted; secondly, it is difficult to maintain the trunk in a vertical position when the subject is seated due to the insufficiency of the abdominal muscles [33]. Thus, when stroke patients attempt to perform the sit-to-stand movement with a retroverted pelvis and kyphotic trunk, the standing up action is affected due to the insufficiency of pelvic anteversion and trunk extension. In addition, Campbell et al. suggested that deficits in the muscle strength and trunk amplitude of stroke patients result in reduced pelvic mobility, apparently as a strategy to protect against a potential risk of loss of balance when reaching in the sitting position [34].

Numerous studies investigating trunk movement have considered the supine position as one segment, ignoring the complexity of intervertebral movement [35]. Campbell et al. indicated that little attention has been paid to how elderly persons coordinate the head, pelvis, and trunk during movement [34]. Studies on the sitting posture of stroke patients have a similar tendency. Few studies have investigated the movement of the spine and pelvis separately. Verheyden et al. reported on pelvic movement during lateral reach movements in the sitting position [36], and Messier et al. described the movements of the upper trunk and pelvis when subjects touched a target placed in front of them with the forehead [37]. To execute the sit-to-stand movement smoothly, the pelvis must be leaned forward to flex the hip joint, and the trunk must be flexed in order to: (1) use the hip extension moment; (2) reduce the knee extension moment; and (3) project the center of gravity within the base of support [38–43].

Pelvic mobility plays an important role in the sit-to-stand movement in elderly people and stroke patients.

This chapter first discusses the age-related changes in the maximum anteversion and retroversion of the pelvic angles in the sitting position [44] and then explores the relationship between the ability to perform the sit-to-stand movement and the maximum pelvic anteversion and retroversion angles in stroke patients [45].

2. The age-related changes in the pelvic angles during sitting

The first section investigated the relationship between age and the maximum pelvic anteversion and retroversion angles, as well as the associated pelvic range of motion, which is measured based on the knee movement in the sitting position [44]. The pelvic range of motion was defined as the difference between the maximum pelvic anteversion and retroversion angles. The hypothesis of the present study was that pelvic range of motion would be affected by aging.

The participants included 132 healthy volunteers (female, $n = 74$; male, $n = 58$) of 20–79 years of age (Table 1). The participants were recruited from a university, two workplaces, and the community near the university. The participants were free from neurological and orthopedic impairments. After the experimental protocol was explained to all of the participants, they gave their informed consent.

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

The pelvic angles were measured based on the sacral inclination angle [46]. An inclinometer with a resolution of 1° was used to measure the pelvic angles. 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 (Figure 1).

The subjects were instructed to maintain the same anteroposterior shoulder position throughout the movements of pelvic inclination to avoid anteroposterior movement of the trunk. The

Age group	<i>n</i>	Maximum pelvic anteversion angle (°)	Maximum pelvic retroversion angle (°)	Pelvic range of motion (°)
20–29 years	<i>n</i> = 48	84.5±3.4	123.1 ± 6.1	38.7 ± 6.0
30–39 years	<i>n</i> = 13	87.8±4.1	125.7 ± 6.8	37.6 ± 9.2
40–49 years	<i>n</i> = 13	90.1±5.4 ^a	124.1 ± 8.9	34.0 ± 8.7
50–59 years	<i>n</i> = 23	88.8±4.6 ^a	118.2 ± 9.8	29.4 ± 8.4 ^{a,b}
60–69 years	<i>n</i> = 19	92.6±6.5 ^{a,b}	117.1 ± 8.7 ^b	24.3 ± 6.3 ^{a,b,c}
70–79 years	<i>n</i> = 16	9.39 ± 4.0 ^{a,b,d}	117.8 ± 9.3	23.8 ± 8.6 ^{a,b,c}

^a Significant difference from 20 to 29 years of age.
^b Significant difference from 30 to 39 years of age.
^c Significant difference from 40 to 49 years of age.
^d Significant difference from 50 to 59 years of age.

Table 1. The mean and standard deviation of the pelvic angles in each age group [44].

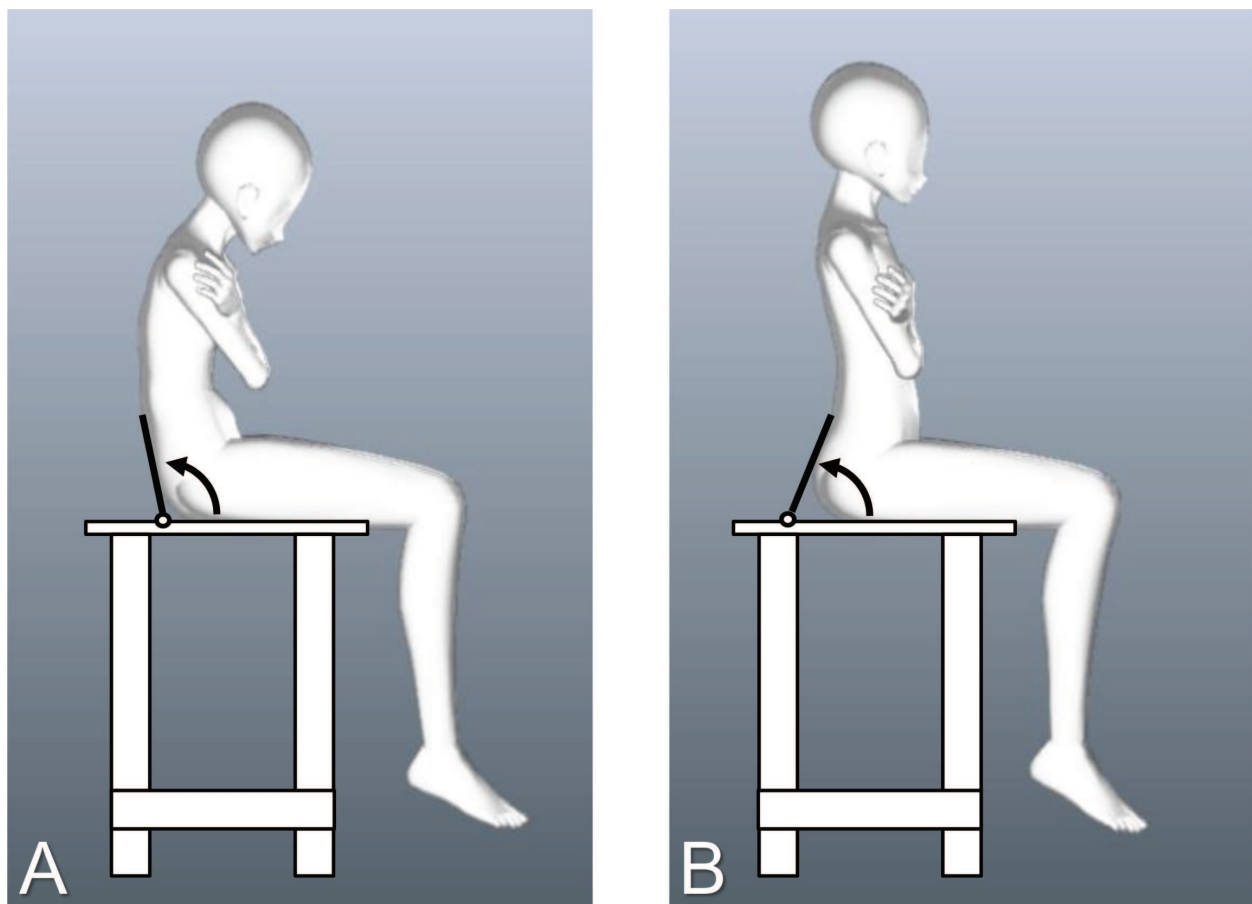


Figure 1. A schematic illustration of the procedure for measuring the pelvic inclination angle: (A) the pelvic retroversion angle, (B) the pelvic anteversion angle [44].

instruction to the subjects was, “Please maintain your shoulder position during pelvic movement.” Participants assumed 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 average maximum pelvic anteversion and retroversion angles.

The maximum pelvic anteversion angle, maximum pelvic retroversion angle, and the range of pelvic motion were significantly affected by aging (**Table 1**).

The maximum pelvic anteversion angles in participants of 40–49, 50–59, 60–69, and 70–79 years of age were significantly smaller than those in participants of 20–29 years of age. The maximum pelvic anteversion angles in participants of 60–69 and 70–79 years of age were significantly smaller than those in participants of 30–39 years of age, and the maximum pelvic anteversion angles in participants of 70–79 years of age were significantly smaller than those in participants of 50–59 years of age (**Table 1**).

With regard to the maximum pelvic retroversion angle, none of the age groups showed a significant difference in comparison to the 20–29 year age group. The maximum pelvic retroversion angle in the participants of 60–69 years of age was significantly smaller than that in the participants of 30–39 years of age (**Table 1**).

The pelvic ranges of motion in participants of 50–59, 60–69, and 70–79 years of age were significantly smaller in comparison to participants of 20–29 and 30–39 years of age. Furthermore, the pelvic range of motion of participants of 60–69 and 70–79 years of age was significantly smaller than that in participants of 40–49 years of age (Table 1).

The relationships between these variables and age were approximated using linear regression equations (Figure 2). These results indicate that pelvic mobility in the sitting position is affected by aging. There was a significant correlation between age and the maximum pelvic anteversion angle ($r = 0.61, p < 0.001$), the maximum pelvic retroversion angle ($r = -0.29, p < 0.05$), and the range of pelvic motion ($r = -0.63, p < 0.001$) (Figure 2).

Hamstring tension probably had an insignificant effect on pelvic mobility in this dataset, especially on the anterior tilt, because the knees could move freely during pelvic movement. The hip flexion angle during maximum pelvic anteversion was 87° and the extension angle during maximum retroversion was 57° in participants of 70–79 years of age. Thus, the 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 was in line with the results of previous studies on lumbar spine mobility, which reported strong correlations between pelvic tilt or the sacral tilt angle, and the lumbar spine lordosis angle in the sitting position [5, 46, 47]. In addition, the pelvic mobility in the sitting position is larger than that in the standing position [6]. Kuo et al. reported that there was a significant correlation between lumbar spine

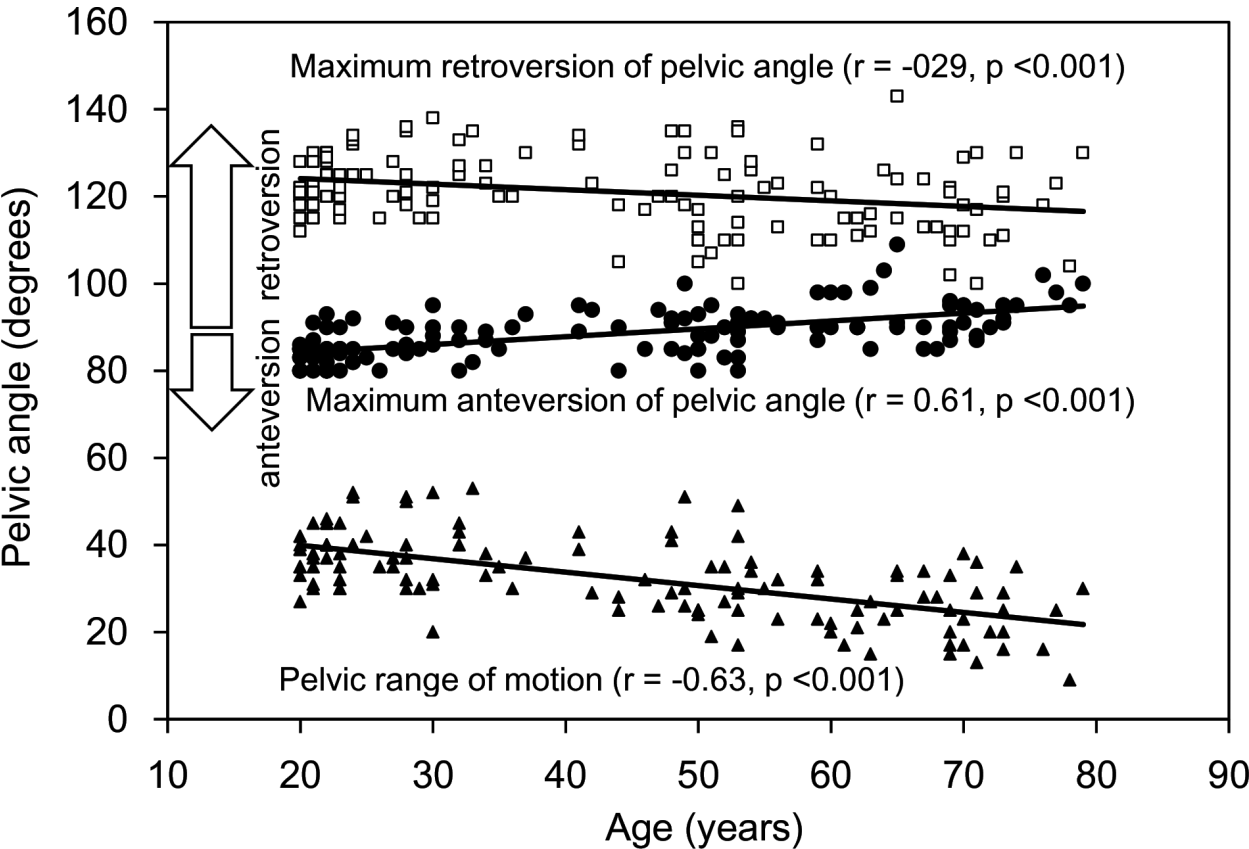


Figure 2. The correlations between age and the maximum pelvic anteversion angle (black circles), the maximum pelvic retroversion angle (white squares), and the pelvic range of motion (black triangles) [44].

mobility and the pelvic tilt angle ($r = 0.67$) in the sitting position [5]. Thus, changes in the maximum pelvic anteversion and retroversion angles that occur with aging might be directly affected by the changes in lumbar spine mobility that occur with aging [11]. When sitting, the angle between the lumbar spine and the pelvis is reduced when leaning forward, especially in elderly individuals. It is considered that thoracic kyphosis becomes more pronounced and that the thoracic and the lumbar spines almost act as one segment to compensate for this reduced lumbar mobility [5].

However, due to the aging-related shortening of the hamstring muscles, the maximum pelvic anteversion angle may be more restricted when performing this movement without the free mobility of the knees.

The pelvic range of movement was approximately 40° in participants of 20–29 years of age and approximately 24° in participants of 60–69 and 70–79 years of age. The rate of pelvic mobility limitation that occurred with aging in this study (approximately 30%) was larger than that previously reported for hip extension (approximately 20%), which is considered to be the joint in the lower extremities that is most limited by aging [48]. Thus, sagittal plane pelvic mobility may be an important factor that is associated with mobility limitation during the sit-to-stand movement in elderly adults.

3. The relationship between the ability to perform the sit-to-stand movement and the pelvic angles in patients with stroke

The sacral sitting posture, which involves a high degree of trunk flexion and neck extension, is frequently observed in stroke patients. This sitting posture is not the ideal posture for smoothly performing the sit-to-stand movement. Maintaining the sitting position with pelvic retroversion may be necessary to increase the sitting stability of stroke patients. However, the ability to achieve anteversion of the pelvis is necessary to perform the sit-to-stand movement.

The second section investigates the relationship between the pelvic anteversion and retroversion angles and the ability to perform the sit-to-stand movement [45]. The hypothesis of this study was that stroke patients who are able to stand from sitting in a chair have a larger maximum pelvic anteversion angle than patients who are unable to stand from a chair.

Thirty-two hemiparetic subjects (female, $n = 15$; male, $n = 17$; age, 66.7 ± 7.6 years) and 50 age-matched healthy control subjects (female, $n = 40$; male, $n = 10$; age, 64.2 ± 8.2 years) participated in this study. The inclusion criteria were predetermined as follows: (1) a poststroke period of more than 3 months and (2) the ability to maintain the sitting position without the use of aids. The hemiparetic subjects were classified into two groups according to their performance in the sit-to-stand movement test (described later): a group with the ability to stand up (the stand-able group; $n = 18$ persons) and the group that was unable to stand up (the stand-unable group; $n = 14$ persons). Patients with a history of low back pain or surgery, hemispatial neglect, bilateral stroke, visual deficit, comprehension impairment, cognitive and/or communication deficits that precluded cooperation, as well as neurological or musculoskeletal disorders that were not related to the current stroke, were excluded. The exclusion criteria for

healthy subjects included known vestibular dysfunction, a history of neurological disease, or orthopedic conditions that had the potential to interfere with the experiment.

The participants sat on the chair, with the front edge of the seat aligned with the point corresponding to 66% of their thigh length from the greater trochanter. The subjects sat with their feet in the parallel position with both arms crossed on their chest and with no support for the trunk or upper extremities. The chair seat height was adjusted to 100% of the subject's lower leg length (the distance from the lateral femoral condyle to the ground); the knee flexion angle was 90° .

The pelvic angles were measured according to the sacral inclination angle (**Figure 3**). Pelvic anteversion was reported as a positive angle and pelvic retroversion was reported as a negative angle. The subjects were instructed to maintain the initial acromion anteroposterior position during the movements to avoid trunk anteroposterior movement. The stroke patients (barefoot) were then asked to stand up at a self-selected speed while keeping the arms folded across the chest. Three trials were performed with no restrictions on the position of the feet. Stroke patients who could independently perform all three trials were classified into the stand-able group. The remaining patients were classified into the stand-unable group.

The maximum pelvic anteversion angle in the stand-able, stand-unable, and control groups ranged from 5 to -4° , -5° to -22° , and 10° to -13° , respectively (**Figure 4**). In the stand-able

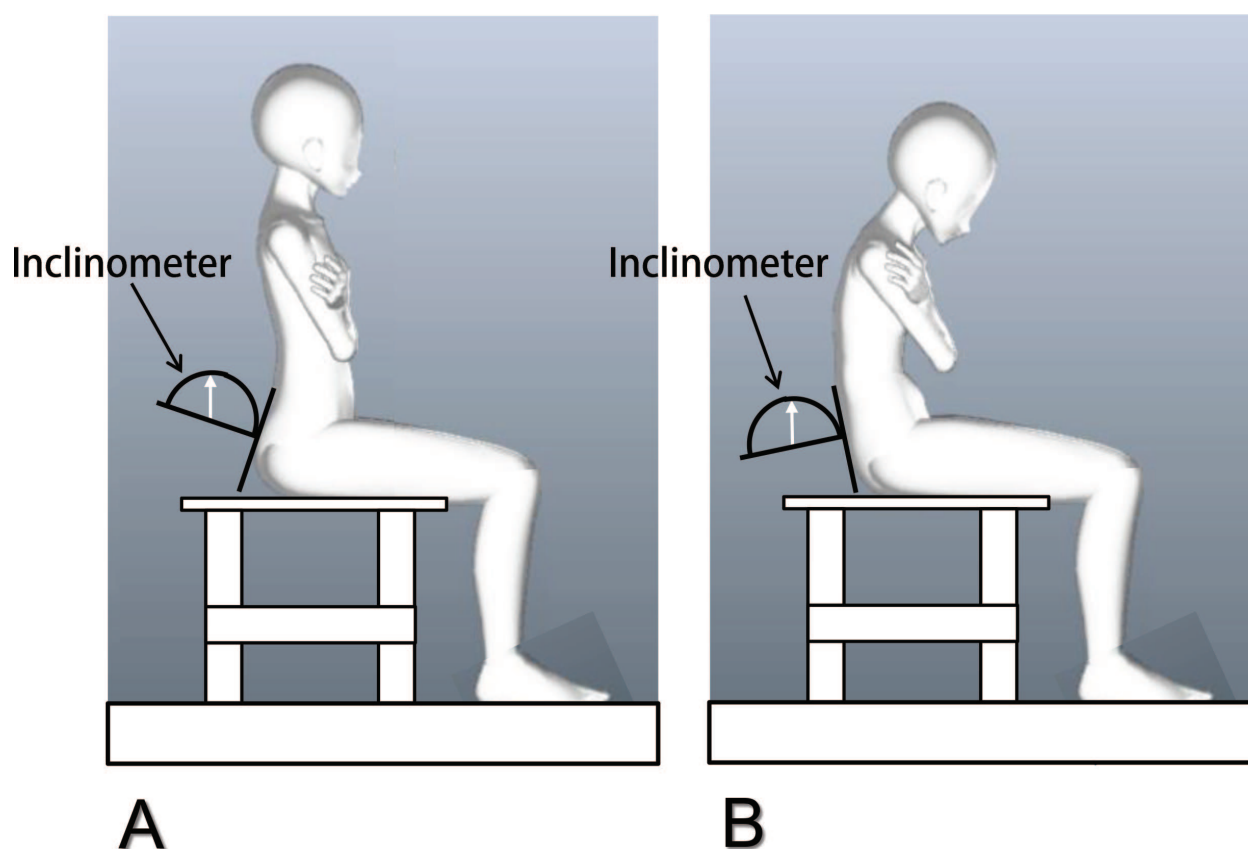


Figure 3. A schematic illustration of the procedure for measuring the pelvic inclination angle: (A) the pelvic retroversion angle, (B) the pelvic anteversion angle [45].

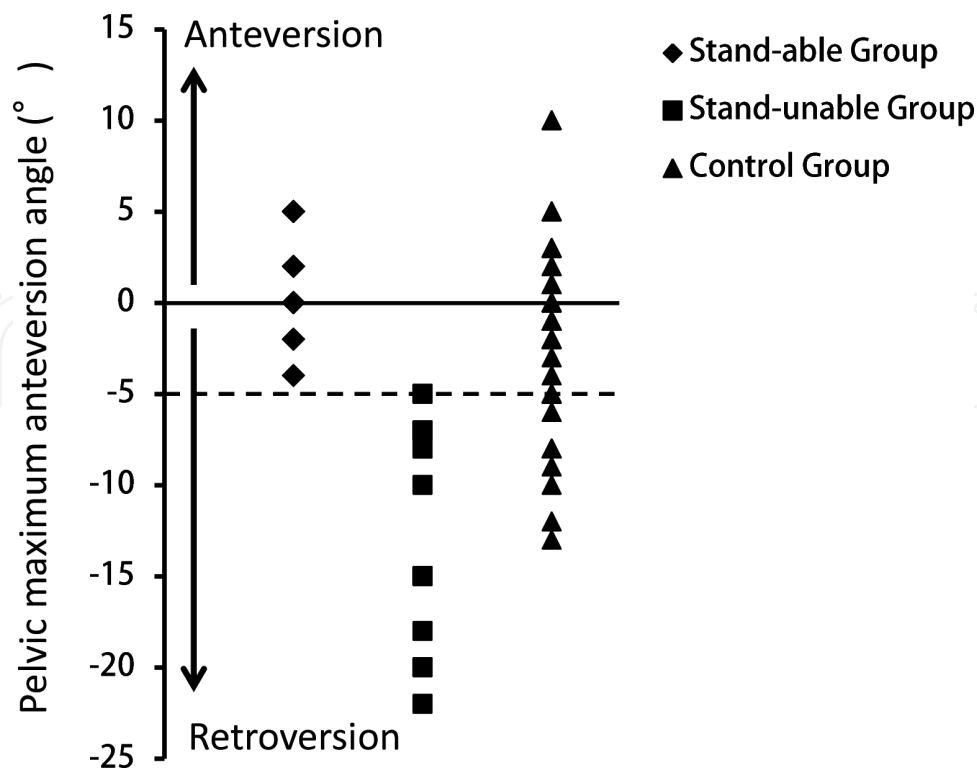


Figure 4. The distribution of the pelvic angles in the stand-able, stand-unable, and control groups.

group, the maximum pelvic anteversion angles were all above -5° ; in contrast, to the angles in the stand-unable group were all below -5° (**Figure 4**). The mean and standard deviation of the maximum pelvic anteversion angles in the stand-able, the stand-unable, and control groups were $1.2 \pm 2.8^\circ$, $-12.4 \pm 6.1^\circ$, and $-1.6 \pm 5.0^\circ$, respectively. The group was found to have a significant main effect ($p < 0.001$). The maximum pelvic anteversion angle in the stand-unable group was significantly smaller than that in the stand-able and control groups (**Table 2**). Thus, it became clear that the maximum pelvic anteversion angle and the range of pelvic motion in the stand-able group were significantly larger in comparison to the stand-unable group.

The maximum pelvic retroversion angles in the stand-able, stand-unable, and control groups ranged from -10° to -30° , -10° to -27° , and -10° to -46° , respectively (**Table 2**). The mean and standard deviation of the maximum pelvic retroversion angles in the stand-able, stand-unable, and control groups were $-18.5 \pm 5.6^\circ$, $-19.6 \pm 4.6^\circ$, and $-27.6 \pm 8.1^\circ$, respectively (**Table 2**). The group was found to have a significant main effect. Significant differences were found between the control group and the stand-able group, and between the control group and the stand-unable group (**Table 2**). The maximum pelvic retroversion angle in the control group was significantly larger than that in both groups of stroke patients (**Table 2**). The maximum pelvic retroversion angles of the stand-able and stand-unable groups did not differ to a statistically significant extent (**Table 2**).

The range of pelvic motion in the in the stand-able, stand-unable, and control groups ranged from 10 to 28° , 0 to 15° , and 9 to 49° , respectively (**Table 2**). The mean and standard deviation of the range of pelvic motion in the stand-able, stand-unable, and control groups was $19.7 \pm 5.1^\circ$,

		Stand-able group (n = 18)	Stand-unable group (n = 14)	Control group (n = 50)
Maximum pelvic	Mean ± SD	1.2 ± 2.8	−12.4 ± 6.1 ^{a,b}	−1.6 ± 5.0
anteversion angle (°)	Range (max–min)	5 to −4	−5 to −22	10 to −13
Maximum pelvic	Mean ± SD	−18.5 ± 5.6 ^b	−19.6 ± 4.6 ^b	−27.6 ± 8.1
retroversion angle (°)	Range (max–min)	−30 to −10	−27 to −10	−46 to −10
Range of pelvic motion	Mean ± SD	19.7 ± 5.1 ^b	7.2 ± 5.1 ^b	25.9 ± 7.6
(°)	Range (max–min)	28 – 10	15 – 0	49 – 9

^a Significant difference from the stand-able group.

^b Significant difference from control group.

Table 2. The mean and standard deviation of the pelvic in the stand-able, stand-unable, and control groups [45].

7.2 ± 5.1°, and 25.9 ± 7.6°, respectively (**Table 2**). The range of pelvic motion in the stand-unable group was significantly smaller in comparison to the stand-able and control groups (**Table 2**).

The hypotheses that the maximum pelvic anteversion angle and the range of pelvic motion in the stand-able group would be significantly larger in comparison to the stand-unable group were confirmed. It is noteworthy that there was a cut-off value maximum pelvic anteversion angle that could divide stroke patients into the stand-able and stand-unable groups. The data suggest that, in order for stroke patients to perform the sit-to-stand movement, the maximum pelvic anteversion angle should be greater than −5°.

To smoothly execute the sit-to-stand movement, the pelvis is anteverted to flex the hip joint and the trunk to perform the hip extension moment, reduce the knee extension moment, and project the center of gravity into the base of support [38–43]. The sitting position stability of stroke patients has been shown to be worse than that in age-matched healthy subjects [5, 11, 12]. It has been shown that stroke patients cannot sufficiently flex the hip joint when it is necessary to activate the trunk extensor muscles during sitting [33]. Stroke patients usually sit with kyphosis and pelvic retroversion to avoid falling backward due to insufficient function of the abdominal muscles. Thus, when performing the sit-to-stand movement, stroke patients may need to lean the trunk further forward to shift the center of gravity into the base of support using their feet due to the increased kyphosis and pelvic retroversion. Lecours et al. observed that, when performing the sit-to-stand movement, the trunk angle during forward leaning in stroke patients was larger than that in healthy subjects [35]. Hesse et al. reported that the average center of gravity projection in the base of support in stroke patients was 3 cm behind that of healthy subjects during the seat off phase in the sit-to-stand movement [49]. In addition, when the trunk is flexed, the hip extension moment becomes insufficient due to the lack of pelvic anteversion; thus, stroke patients may depend primarily on the knee extension movement to stand up.

Some studies have reported a high correlation between pelvic inclination in the sitting position and the degree of lumbar lordosis [5] and a strong relationship between the sacral angle of inclination and the degree of lumbar lordosis [46, 47]. Hence, pelvic inclination (anteversion and retroversion) reflects lumbar movement (lordosis and kyphosis). The range of pelvic

motion in the stand-unable group was extremely limited, reaching merely 28% of the control group and 36% of the stand-able group. Accordingly, in the stand-unable group, the lumbar spine movement in the sagittal plane (lordosis and kyphosis) was probably limited in comparison to the control group and the stand-able group.

The pelvic angle measurements were conducted in the sitting position while the subject maintained 90° of knee flexion with their feet in contact with the ground. In the sitting position, the hip joints work as pivotal axes in pelvic anteversion and retroversion. One factor that should influence the range of motion of the hip is the extensibility of the hamstrings, which drive the hip and knee as biarticular muscles. Hamstring stretching was shown to improve the pelvic anteversion angle [17] and the mobility of the hip in elderly individuals [16]. The sitting position in this study fixed the knee flexion angle at 90°, which should have increased hamstring tension during the measurement. Thus, it is likely that pelvic anteversion was restrained by the increased tension of the hamstrings.

Cheng et al. reported the following three characteristics of the sit-to-stand movement of stroke fallers, the stroke nonfallers, and healthy subjects: stroke patients, especially fallers, required a significantly longer time to perform the sit-to-stand movement; the rate of increase in vertical force (%BW/sec) in stroke fallers was significantly lower in comparison with nonfallers and healthy subjects; and the overshoot of vertical force (%BW) in stroke fallers was significantly lower than that in nonfallers and healthy subjects [50]. These characteristics of stroke fallers may be associated with their limited pelvic anteversion during the sit-to-stand movement. Messier et al. suggested that, to execute the trunk flexion task, stroke patients used a compensatory strategy that consisted in using mainly the upper trunk flexion because they were unable to tilt their pelvis anteriorly [37]. Thus, our data, which showed that the maximum pelvic anteversion angle of the stand-unable group was significantly smaller than that of the stand-able and control groups, were supported by these reports. Another point of view that should be mentioned is that Prudente et al. suggested that neuromuscular coordination abnormalities occurred in both of the lower limbs of stroke patients during the sit-to-stand movement [51].

On the other hand, since there was no significant difference in the maximum pelvic retroversion angle of the two stroke groups, it becomes clear that this angle does not affect the patient's ability to perform the sit-to-stand movement. However, it was also demonstrated that the range of pelvic motion in stroke patients was markedly restricted in comparison to healthy subjects. In stroke patients, pelvic anteversion appears to be an important factor for regaining the ability to perform the sit-to-stand movement.

4. Relevance to physical therapy

This session demonstrated that the pelvic range of motion was affected by aging, particularly in the anteversion angle, and that the maximum pelvic anteversion angle and the range of pelvic motion in the stand-able group were significantly larger than those in the stand-unable group. Notably, if these patients are to be able to perform the sit-to-stand movement, it is important that they acquire a pelvic anteversion angle of greater than -5° .

The mobility of the lumbar spine, which is associated with the strength and coordination of the trunk and the lower limbs, should be considered as the background of these results. The physical therapy program described below would help as an initial step for improving the physical function of elderly individuals and stroke patients—especially with regard to improving their sit-to-stand movement.

For elderly individuals: (1) pelvic anteversion and retroversion—the patient should maintain a seated position with their feet contacting the floor in a parallel position and move slowly, alternating the pelvis from maximum anteversion to maximum retroversion. They should maintain the same shoulder anteroposterior position throughout the pelvic inclination movements in order to avoid anteroposterior movement of the trunk. (2) Leaning the trunk forward with pelvic anteversion—the patient should lean their trunk forward maintaining pelvic anteversion in a seated position with their feet contacting to the floor. This movement should be performed slowly and repeated. It is important to perceive the increasing load to the lower limb during the leaning of the trunk.

For stroke patients: as soon as the stroke patient has obtained an independent sitting position, the treatment should focus on the mobility of the trunk and weight transfer to the lower limbs, using the same methods as for elderly individuals.

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