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Original Article

Hip rotation range of motion in sitting and prone positions in healthy Japanese adults

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Abstract. [Purpose] The aim of this study was to elucidate the difference in hip external and internal rotation ranges of motion (ROM) between the prone and sitting positions. [Subjects] The subjects included 151 students. [Methods] Hip rotational ROM was measured with the subjects in the prone and sitting positions. Two-way repeated measures analysis of variance (ANOVA) was used to analyze ipsilateral hip rotation ROM in the prone and sitting positions in males and females. The total ipsilateral hip rotation ROM was calculated by adding the measured values for external and internal rotations. [Results] Ipsilateral hip rotation ROM revealed significant differences between two positions for both left and right internal and external rotations. Hip rotation ROM was significantly higher in the prone position than in the sitting position. Hip rotation ROM significantly differed between the men and women. Hip external rotation ROM was significantly higher in both positions in men; conversely, hip internal rotation ROM was significantly higher in both positions in women. [Conclusion] Hip rotation ROM significantly differed between the sexes and between the sitting and prone positions. Total ipsilateral hip rotation ROM, total angle of external rotation, and total angle of internal rotation of the left and right hips greatly varied, suggesting that hip joint rotational ROM is widely distributed.

Key words: Hip rotation, ROM, Positions

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INTRODUCTION

In clinical physical therapy, evaluation of range of motion is one of the most important functional evaluation methods. Its importance can be inferred from its use.

According to Norkin et al.[1)], “goniometric data, used with other information, can provide a basis for: determining the presence or absence of dysfunction, establishing a diagnosis, developing treatment goals, evaluating progress or lack of progress toward rehabilitation goals, modifying treatment, motivating the subject, researching the effectiveness of specific therapeutic techniques or regimens, for example, exercises, medications, and surgical procedures, and fabricating orthoses and adaptive equipment”.

Hip internal and external rotations occur along the same axis. The ranges of motion of the two movements are both 45°. Therefore, hip internal and external ranges of motion are important for assessing laterality. Some studies have reported the importance of these ranges of motion. For instance, Kishi et al.[2)] reported that left hip rotation range of motion was lower in subjects with low back pain than in those without low back pain. With regard to muscle strength, Uritani et al.[3)] compared isometric strength measured at three different positions affected by hip flexion during hip internal rotation.

There are four basic, representative positions for measuring hip rotation range of motion: (1) supine position with 90° flexion of the hip and knee[4)], (2) sitting position[1)], (3) prone position with 90° knee flexion[5, 6)], and (4) supine position with 0° hip extension and 90° knee flexion[7, 8)]. In each of the four positions, the knee is in 90° flexion.

This means that methods (1) and (2) use 90° flexion of both the hip and knee, while methods (3) and (4) use 0° hip extension and 90° knee flexion. Several studies have indicated that the limiting factor at the ends of the range of motion differs depending on the position of the hip and knee joints.

In Japan, Murayama et al.[8)] studied laterality and hip rotation range of motion in positions (1), (2), and (4) and reported that the ranges of motion of the hip internal and external rotations varied depending on the position. Kondou et al.[5)] studied the relationship between the angle of anteversion of the femoral neck and hip rotation range of motion by measuring hip rotation range of motion with hip flexion and extension. It was reported that hip rotation range of motion depends on gender, position, and physical characteristics. Hip rotational ranges of motion were measured by image processing software using images of 24 male and female

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subjects taken by a digital camera.

In France, Kouyoumdjian et al.[7] reported a comparison of right and left hip rotation range of motion in three positions in 120 subjects aged 20–60 years. According to their study, hip rotation range of motion decreased with age and was lower in men and overweight subjects. Three measurement positions were used: supine with hip extended, prone with hip extended, and seated with hip flexed. Measurements were taken using digital camera images.

The limiting factors are different for hip rotation range of motion in the prone and sitting positions; it is believed this is due to the different planes and axes of motion in the two positions. Measurement in the prone position has been used clinically, as the pelvis could be stabilized better in the prone position than in the sitting position[9]. However, related research is still scarce.

This study included healthy Japanese adults, and it can be referenced for conducting similar studies in countries with different lifestyles. The results of this study indicate it is helpful to compare hip rotation range of motion in different positions. Additionally, this study demonstrated a gender difference in hip rotation range of motion that will be helpful in clinical evaluation and the health field in the future.

The primary purpose of this study was to examine differences in range of motion of hip external and internal rotation in the prone and sitting positions in healthy adult Japanese men and women. A secondary purpose was to examine the variability in ipsilateral total hip rotation range of motion (the sum of the ipsilateral external and internal rotation ranges of motion).

Table 1. Subject characteristics (mean ± SD)

	Total	Men	Women
	n=151	n=117	n=34
Age (years)	21.8±4.2	21.9±4.4	21.6±3.5
Range	20–53	20–53	20–38
20–29 (n)	145	112	33
30–39 (n)	4	3	1
Over40 (n)	2	2	0
Height (cm)	168.3±7.3 [a]	171.0±5.3	158.9±5.6 [a]
Weight (kg)	60.7±10.6 [b]	62.4±9.5	54.2±12.2 [b]
BMI (kg/m²)	21.3±3.3 [b]	21.3±3.0	21.4±4.6 [b]

BMI: body mass index, n: The number of subjects
[a]The number of subjects included was one less than the above reported number of subjects.
[b]The number of subjects included was four less than the above reported number of subjects.

SUBJECTS AND METHODS

Subjects

The subjects included 154 healthy Japanese students undergoing medical-technician training. The measurements of three subjects were excluded by the Grubbs-Smirnov test[10]. Of the remaining 151 subjects (117 males, 34 females), all 302 hip joints were studied. The characteristics of the subjects are shown in Table 1.

Data collection was conducted from April 2008 to October 2009. Due to a lack of cooperation, height and body weight are missing for one female subject, and body weight is missing for three female subjects. The inclusion criteria were performance of activities of daily living and walking ability at levels sufficient to enable independent living in Japan. The exclusion criteria were non-Japanese race, age older than 60 years, lower leg fracture, self-declared pregnancy, paralysis, or arthritis of the lower extremities or pelvis due to sprain.

Methods

Tokyo University-type metal goniometers with 1° increments and therapeutic beds were used to perform measurements. Measurements collected included left and right hip external and internal ranges of motion in the prone and sitting positions. The measurements were performed according to the "Method Guidelines for Range of Motion Measurement"[4] of the Japanese Association of Rehabilitation Medicine and the Japanese Orthopaedic Association. According to this method, the basic axis is a vertical line drawn from the patella, and the moving axis is the center line of the lower leg, marked as a line from the center of the patella to the midpoint between the medial and lateral malleoli. These axes were used for both the sitting and prone positions.

During measurement, a double-blind method was used wherein the measurer and subject were not informed of the values until the end. The measurement order for the different ranges of motion was determined by drawing lots beforehand. Each range of motion for each position was measured three times by the passive method.

Measurements were taken by third-year physical therapy or occupational therapy students under the guidance of a physical therapist. Examiners performed one of four roles: moving the hip, operating the goniometer, recording, and observing any compensatory movements. The examiner moved the hip joint toward the end of the range of motion by pushing the neck of the foot of the subject. At the end of the range of motion, the goniometer operator aligned the goniometer to the basic and moving axes, and the recorder recorded the value of the angle. To prevent compensatory movements, one to three students observed the testing.

During measurement in the sitting position, the hips and knees were adjusted prior to the measurement as follows: The hip joint was placed at 90° flexion in the neutral position between abduction and adduction, and the knee joint was adjusted to 90° flexion. The hip was passively rotated for range of motion measurements. During measurement of hip external rotation range of motion, the contralateral knee was flexed less than 90° to avoid impeding the motion. When contralateral knee flexion was difficult, the contralateral knee was extended. To prevent compensatory movement, hip adduction or abduction, hip lifting from the table, and abduction of the trunk were prevented during the range of motion measurements.

During measurement in the prone position, the position was set to avoid an unbalanced position of the neck and trunk for each subject. The head was set beneath the intermediate position, and the upper and lower limbs were balanced on the

Table 2. Hip rotation range of motion (mean ± SD [°])

		Internal rotation		External rotation	
		Sitting†	Prone†	Sitting†	Prone†
Total	Left	41.9±8.5	45.8±10.8	42.8±8.1	51.9±11.4
n=151	Right	43.5±8.0	47.4±9.8	42.2±8.9	50.6±10.8
Male*	Left	40.6±8.0	44.2±10.1	43.2±8.1	53.2±11.2
n=117	Right	42.1±7.0	45.6±8.5	43.1±9.1	51.7±10.9
Female*	Left	46.4±8.8	51.4±11.4	41.4±7.8	47.7±11.2
n=34	Right	48.2±9.5	53.5±11.6	39.0±7.6	46.8±10.0

*Significant difference between men and women ($p < 0.05$)
†Significant difference between sitting and prone positions ($p < 0.05$)

Table 3. Total ipsilateral hip rotation range of motion (mean ± SD [°])

		Sitting position (IR+ER)		Prone position (IR+ER)	
		Left	Right	Left	Right
Total	(n=151)				
	Mean±SD	84.7±13.6	85.6±14.0	97.8±17.8	98.1±16.0
	Range (min-max)	46–128	49–132	55–152	58–132
Male	(n=117)				
	Mean±SD	83.8±13.5	85.2±13.6	97.3±17.7	97.4±15.2
	Range (min-max)	59–128	56–132	55–152	65–132
Female	(n=34)				
	Mean±SD	87.8±13.9	87.2±15.3	99.2±18.2	100.3±18.7
	Range (min-max)	46–120	49–123	62–134	58–130

IR: internal rotation, ER: external rotation

right and left sides. The trunk was set to a median position to avoid trunk lateral flexion or rotation. During measurement of hip internal and external ranges of motion, the ipsilateral knee joint was flexed 90°. To prevent the hip lifting from the table during hip rotation, the pelvis was stabilized by manual pressure. Simultaneously, the ipsilateral lower leg was moved to the end of the hip internal rotation range of motion. When the contralateral lower extremity impeded hip external rotation range of motion, the hip joint was placed in an abducted position.

Mean values of the three measurements were calculated and rounded off. The total ipsilateral hip rotation range of motion was calculated by adding up the mean values of the external and internal rotations on the left and right sides, respectively.

The total sum of the same kind of hip rotation range of motion was calculated by adding the mean left and right values of the same kind of hip rotation range of motion; that is, the right external rotation was added to the left external rotation, and the right internal rotation was added to the left internal rotation.

The minimum and maximum values were determined for both the total ipsilateral hip rotation range of motion and the total sum of the same kind of hip rotation range of motion.

A two-way repeated measures analysis of variance (ANOVA) was used to analyze ipsilateral hip rotation range of motion in the prone and sitting positions in men and women, and the significance level was set at 5%. Analyses were performed using the IBM SPSS Statistics21 software.

For the subject's safety, a physical therapist, occupational therapist, and nurse ensured that the measurement method for hip rotational range of motion was not dangerous prior to starting measurements. As an ethical consideration, the study content and purpose were described to the subjects, who provided written or verbal approval prior to participation.

RESULTS

Two-way repeated measures ANOVA of the ipsilateral hip rotation ranges of motion of men and women in the prone and sitting positions revealed significant differences, showing a main effect in each position for both the left and right hip internal and external rotation ranges of motion. For position, hip rotation range of motion in the prone position was significantly higher than that in the sitting position. For gender, the left and right hip external rotation ranges of motion were significantly higher in both positions in men than in women. Conversely, hip internal rotation range of motion was significantly higher in both positions in women than in men (Table 2).

An interaction between gender and position was not observed.

For the total ipsilateral hip rotation range of motion, the minimum and maximum values were 46° and 132°, respectively, in the sitting position and 55° and 152°, respectively,

Table 4. Total sum of the same kind of hip rotation ROM on both sides (Mean ± SD [°])

		Internal rotation (Rt+Lt)		External rotation (Rt+Lt)	
		Sitting	Prone	Sitting	Prone
Total	(n=151)				
	Mean±SD	85.4±15.4	93.2±19.3	84.9±15.8	102.6±21.1
	Range (min-max)	50–140	45–144	40–148	50–158
Male	(n=117)				
	Mean±SD	82.8±13.8	89.8±17.3	86.3±16.2	104.9±21
	Range (min-max)	50–125	45–139	57–148	50–158
Female	(n=34)				
	Mean±SD	94.6±17.1	104.9±21.3	80.4±13.9	94.6±20.0
	Range (min-max)	55–140	65–144	40–103	51–135

Lt: left, Rt: right

in the prone position (Table 3).

For the total sum of the same kind of hip internal rotation range of motion, the minimum and maximum values were 50° and 140°, respectively, in the sitting position and 45° and 144°, respectively, in the prone position (Table 4). For the total sum of the same kind of hip external rotation range of motion, the minimum and maximum values were 40° and 148°, respectively, in the sitting position and 50° and 158°, respectively, in the prone position (Table 4).

DISCUSSION

The left and right hip internal and external rotation ranges of motion in the prone position were significantly higher than all sitting position measurements; this is believed to be due to the positional factors limiting range of motion at the end of the motion.

It can be considered that the limiting factor for the end range of motion is different between positions; the hip joints are flexed in the sitting position but are in an intermediate position in the prone position.

Simoneau et al.[11] reported that the difference in hip rotation range of motion by measurement position is influenced by not only ligaments around the hip joint but also by the joint capsule and muscle tendons. Soft tissues limiting range of motion are divided into capsular and non-capsular patterns, as described below[1, 12, 13].

The limitation of the capsular pattern is that pathological conditions involving the entire joint capsule cause a particular pattern of limitation involving all or most passive joint motions. The limitations do not involve a fixed number of degrees for each motion; rather, they involve a fixed proportion of one motion relative to another motion[1, 12].

The non-capsular pattern is usually caused by a condition involving structures other than the entire joint capsule. Such conditions may include internal joint derangement, adhesion of a part of a joint capsule, ligament shortening, muscle strains, and muscle contractures. Non-capsular patterns usually involve only one or two motions of a joint[1, 12, 13].

In addition, because hip range of motion in the prone position is greater than that in the sitting position, range of motion may possibly be influenced by gravity[11]. As the measurement method was passive, the operator's perception of the end of the range of motion possibly differed by position. During measurement of hip range of motion in the prone position, the lower leg should be moved down. When moving the lower leg downward when measuring with the subject in the prone position, the operator feels "lighter" at the end of the range of motion. By contrast, the operator feels "heavier" when moving the lower leg upward with the subject in the sitting position.

Hence, position may have affected the operator's perception of the end of the range of motion. The present study supports this previous research in that there was a tendency for hip range of motion in the prone position to be greater than in the sitting position.

Regarding gender differences in hip joint range of motion, external rotation was higher in men, but internal rotation was higher in women (Table 2). Regarding positional differences in hip rotational range of motion, it has been reported[14, 15] that "structural antetorsion of the hip was present when the asymmetry of medial rotational range of motion was much greater than the lateral rotational range in both the hip flexed and the hip extended positions. In the case of retrotorsion, the range of motion lateral rotation should be greater than the range of medial rotation in both the flexed and extended positions of the hip. With the hip extended and the knee flexed, none of the musculature that limits medial rotation is taut. In the hip flexed position the gluteus maximus is pulled taut and can limit the medical rotational range of motion".

There have been a number of studies reporting hip rotation range of motion, including those by Okabe et al.[16], Shimada et al.[17], Tamari et al.[18], Murayama et al.[8], and Takemasa et al[19].

In regard to gender differences in hip rotation range of motion, Kondou et al.[5] compared hip antetorsion and hip rotation range of motion with the hip flexed and extended and reported that taking measurements with the hip flexed reduced hip rotation range of motion more than taking measurements with an extended hip. These reports suggested a greater tendency of antetorsion in women, which is consistent with the present results.

On the other hand, the current study observed a significant difference between positions in both women and men. This may result from the increased power of the present study due to the greater number of subjects. In the present and previous studies, external rotation in men was greater than that in women, and internal rotation was greater in women than in men.

This study found similar results and supports the prior studies. Kendall et al.[20] reported that “a tight tensor fasciae latae may be a contributing cause, and sitting in a reverse tailor or ‘W’ position may predispose toward faulty hip, knee, and foot positions. There may be a structural malalignment with a lateral tibial torsion accompanying the hip medial rotation”.

One factor possibly affecting gender differences in hip range of motion is gender differences in the Japanese lifestyle. In Japan, men more commonly perform external hip rotation because of sitting cross-legged on the floor on a tatami, whereas women more commonly perform internal hip rotation due to frequently sitting straight in the reverse tailor position or in a sideways position since childhood.

In the present study, there were no interactions between gender and position, suggesting that the gender difference in range of motion is not likely due to positional change.

For the total ipsilateral hip rotation range of motion (Table 3), the total sum of hip rotation range of motion, total value of internal rotation, and total value of external rotation (Table 4), the difference between the maximum and minimum values was great between the prone and sitting positions. These results suggest that flexibility of the hip joint in healthy individuals is widely distributed.

For the purpose of evaluation of joint range of motion, Matsuzawa et al.[21] listed that “to determine factors inhibiting joint movement, the judgment of the severity of impairments, to give an indication to the treatment, the judgment of the therapeutic effect.”

As measuring range of motion is an important part of evaluation, there are an increasing number of studies examining hip rotational range of motion. For example, Sato et al.[22] investigated the influence of hip external rotators on hip flexion in healthy subjects, finding that flexion angle decreased significantly with increasing internal rotation angle. Moreover, in sports research[23], hip rotation range of motion may help predict throwing-related disorders[24]; consequently, studies have examined muscle activity and motion, including the effect of hip internal and external rotation range of motion and its relationship to trunk muscle activity during standing. For example, such studies include that of Nojima and Sasaki[25]. In addition, there has been research on the effects of therapeutic intervention affecting hip rotation, and there is a movement to provide improved assessment of hip rotation range of motion.

A limitation of this study is that it was limited to subjects recruited from Gunma Prefecture in Japan. Thus, further study is required to determine whether these subjects were representative of all healthy Japanese adults. Moreover, as most of the subjects were in their early 20s, it was not representative of all age ranges. Finally, all subjects were medical school students.

All examiners were third-year students and had received training about measurement methods for joint range of motion. Inter- and intra-rater reliability were also not considered.

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