



Original Article

Ipsilateral patterns of the rotational range of motion of the hip in healthy Japanese adults

HEONSOO HAN, PT, PhD¹*, AKIRA KUBO, PT, PhD¹, KAZUO KUROSAWA, PT, PhD², SHIZUKA MARUICHI, PT³, MASAHIRO ISHIZAKA, PT, PhD¹, KAORI SADAKEYO, PT, MS¹, TAKAHIRO NOMURA, PT, PhD¹, KAORU HONZAWA, PT, MS¹

¹ Department of Physical Therapy, School of Health Sciences, International University of Health and Welfare: 2600-1 Kitakanemaru, Ohtawara City, Tochigi 324-8501, Japan

² Department of Physical Therapy, School of Health Sciences at Odawara, International University of Health and Welfare, Japan

³ Self-employed Physical Therapist, Japan

Abstract. [Purpose] This study aimed to categorize the internal and external rotation range of motion (ROM) of ipsilateral hip joints into specific patterns based on the differences between them, and clarify the distribution of these patterns. [Subjects and Methods] A total of 222 healthy Japanese medical students (162 males, 60 females) with a mean age of 21.2 ± 4.0 years were enrolled. The ROM of internal and external rotation at the hip were randomly measured with the subjects in the prone position. Thereafter, the difference between internal and external rotations was assessed. Hip ROM patterns were classified into 3 types based on the differences in the rotation ROM on each side. A total of 9 overall patterns were then determined based on the combination of patterns on both sides. [Results] Although all the subjects were healthy, an asymmetrical ROM between internal and external rotation in ipsilateral hip joints could be detected via pattern classification. Moreover, the distribution of each hip ROM pattern was clarified. [Conclusion] Pattern classification based on differences in internal and external rotation ROM could serve as a useful evaluation method for clinical manipulative therapy.

Key words: Hip rotation, ROM, Pattern

(This article was submitted Apr. 6, 2016, and was accepted May 23, 2016)

INTRODUCTION

In general, a normal condition in humans is considered to indicate a healthy state, whereas an abnormal condition is considered to indicate a state of illness. However, the boundary between healthy and pathological conditions is not always clear, and diagnoses cannot be considered accurate in all instances. The precision of diagnoses can be represented by their positive or negative predictive value, as well as the sensitivity, specificity, and likelihood ratio¹).

Accordingly, it means that there is the probability of diagnosing a condition as a disease in an individual without any abnormality. In contrast, it is also possible that an individual with an abnormality is diagnosed as not having any disease. Besides such potential errors in diagnosis, a state exists in humans that may be classified neither as healthy nor as diseased. This state is referred to as non-illness²) in oriental medicine. Even if an abnormality is present in such cases, medical examination may not identify it as such. Some types of musculoskeletal system disease may present in such a state of non-illness.

Several explanations for cases of musculoskeletal system disease, typically citing the term subluxation, have been suggested by Gatterman³). In fact, there are a total of 105 such terms, including hypermobility, hypomobility, and sprain. These terms are considered to refer to joints that are not normal. Thus, musculoskeletal system disease is an important target in physical therapy. The concept of an intermediate boundary between the normal and abnormal state of a joint has not yet been

*Corresponding author. Heonsoo Han (E-mail: han@iuhw.ac.jp)

©2016 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<http://creativecommons.org/licenses/by-nc-nd/4.0/>>.

fully established. Nevertheless, the prevention of progression to clear abnormality in cases at this intermediate state can be useful.

Internal and external rotations of the hip occur in the same axis with a typical 45° range of motion (ROM). Hence, it is important to assess the deviation in the ROM between internal and external rotation in clinical physical therapy. The ROM of internal and external rotation of the hip have been used as an indicator of manipulative therapy in the clinical setting. In fact, some methods in clinical physical therapy are used to treat unbalanced rotational ROM at the hip, including stretches and muscle strengthening exercises.

A previously reported special technique is based on a conventional theory of the interlocking movement of hip joint rotation. The principle underlying this technique is that the rotational ROM of the hip joint of the left and right sides are linked with each other. Thus, the ROM of internal rotation will increase on one side when external rotation decreases on the same side. In contrast, on the contralateral side, internal rotation will decrease, whereas external rotation will increase. Thus, in such cases with an abnormality on one side, the treatment approach could be initiated from the other side. This method could be used to adjust the unbalanced rotational ROM at the hip joint.

These patterns in external and internal rotation are reported to be linked in certain studies, whereas no linkage has been found in other studies. Kishi et al.⁴⁾ reported that left hip rotational ROM was lower in subjects with low back pain than in subjects without low back pain. Uritani et al.⁵⁾ noted that isometric strength, measured at three different positions, was affected by hip flexion during hip internal rotation.

With regard to the classification of patterns of the rotational ROM in the hip, studies on patterns in individuals with low back pain⁶⁾, on the pattern and strength of ROM in healthy individuals⁷⁾, and on the laterality and measurement position of rotational ROM⁸⁾ have been reported. Although these studies have compared the pattern of difference between internal and external rotation⁷⁾, none of the previous studies have simultaneously investigated the patterns only on one side. Furthermore, no studies investigating the classification of patterns of hip rotation ROM in healthy Japanese male and female subjects have been reported. Although the subjects may be healthy, the presence of a deviation in hip rotation ROM, i.e., asymmetric internal and external rotation, should prompt an investigation.

The present study aimed to classify the rotational ROM of the hip based on the difference in patterns of internal and external rotation, and to determine the distribution of rotational balance patterns of ipsilateral and bilateral rotational ROM at the hip among healthy Japanese male and female subjects. Moreover, the presence of asymmetry in hip rotation and the distribution of the patterns on the same side were determined. In addition, the presence or absence of antagonizing patterns and the proportion of individuals with such antagonizing patterns were identified.

SUBJECTS AND METHODS

A total of 222 healthy Japanese medical students (162 males, 60 females) with a mean age, height, and body weight of 21.2 ± 4 years, 167.8 ± 8 cm, and 60.4 ± 10.2 kg, respectively, were enrolled. The characteristics of the subjects are presented in Table 1. The inclusion criteria, the presence of independent movement and ability to walk in daily life, were self-reported by the subjects. Subjects who were pregnant; those with paralysis or fractures to the pelvis and lower extremities, or arthritis of the lower limbs; those undergoing treatment for sprains; and those aged >60 years were excluded from the study.

The ROMs of internal and external rotation of the hip were measured on the right and left sides with the subject in the prone position⁹⁾. The measurements were recorded in 1° increments, using metal goniometers.

The measurements were performed according to the “Methods and guidelines for the measurement of joint range of motion (in Japanese)”^{9, 10)} by the Japanese Association of Rehabilitation Medicine and the Japanese Orthopaedic Association. Accordingly, the basic axis was considered as the vertical line drawn from the patella, whereas the moving axis was considered as the center line of the lower leg. Measurements were obtained by second- or third-year physical therapy or occupational therapy students under the guidance of a physical therapist.

During measurement, a double-blind method was used, wherein the examiner and subject were not informed of the values until the end of the examination. The order of measurement of the different ROMs was determined by drawing lots. Each ROM was measured three times for each item (internal and external rotation on both sides) using a passive method. With regard to measurements in the prone position, the subject was placed so as to avoid an unbalanced position of the neck and trunk.

Table 1. Characteristics of the subjects (mean ± SD)

	Total	Male	Female
	n=222	n=162	n=60
Age (years)	21.2 ± 4.0	21.2 ± 4.0	21.2 ± 4.2
Height (cm)	167.8 ± 8.0	171.2 ± 5.7	158.5 ± 5.4
Weight (kg)	60.4 ± 10.2	62.8 ± 9.3	53.9 ± 9.7
BMI (kg/m ²)	21.4 ± 3.0	21.4 ± 2.8	21.4 ± 3.6

During the measurement of internal and external rotation ROM of the hip, the ipsilateral knee joint was flexed to 90°. To prevent the lifting of the hip from the table during hip rotation, the pelvis was stabilized using manual pressure. Simultaneously, the ipsilateral lower leg was moved to the end of the hip's internal rotation ROM. When the contralateral lower extremity impeded the external rotation ROM, the contralateral hip joint was placed in an abducted position.

The mean values of the three measurements were calculated by Microsoft Excel.

A one-way repeated-measures analysis of variance (ANOVA) was used to analyze ipsilateral hip rotation ROM in male and female subjects, and the significance level was set at 5%.

The patterns of hip rotation ROM were classified based on the differences between internal and external rotation on the same side. The criteria for the classification of the rotation ROM of the hip joint to a specific pattern was a difference of 10°. As the ROM is measured in the clinical setting in 5° intervals, the use of a value of 5° could lead to potential errors in classification. The differences in the patterns of ipsilateral hip rotation ROM were classified based on the differences between internal rotation and external rotation as follows: balanced pattern (IR≈ER), when almost no difference (0–9°) was observed between internal rotation and external rotation; internal rotation greater pattern (IR>ER), when the value of internal rotation was >10° relative to the value of external rotation; and external rotation greater pattern (IR<ER), when the value of external rotation was >10° relative to the value of internal rotation (Table 3).

The differences in the ipsilateral patterns between the right and left sides and between male and female subjects were assessed using the chi-square test (Table 3). After combining the ipsilateral patterns of the left and right sides, a total of 9 patterns were identified (Table 4).

After classifying the overall combination patterns based on the differences between internal and external rotation in the ipsilateral joint on the left and right sides, the appearance rate and the number of occurrences of the hip joint according to each pattern were determined. The mean and maximum values of the difference between internal rotation and external rotation were estimated (Table 4). The number of subjects exhibiting a combination of the 9 patterns was examined according to gender by using the χ^2 test (Table 4).

Table 2. Distribution of the rotational range of motion of the hip joint (°)

		Left IR	Left ER	Right IR	Right ER
Total n=222	Mean ± SD	45.7 ± 11.2	53.4 ± 12.1	47.8 ± 11.1	52.2 ± 11.6
	Range (Min–Max)	16–75	27–85	21–79	24–83
	Median	45	53	47	52
Male n=162	Mean ± SD	43.2 ± 10.0**	54.7 ± 12.0*	45.0 ± 9.1**	53.5 ± 11.3*
	Range (Min–Max)	16–75	28–85	21–67	20–83
	Median	42	54	45	53
Female n=60	Mean ± SD	52.6 ± 11.4**	50.0 ± 11.9*	55.4 ± 12.4**	48.5 ± 11.8*
	Range (Min–Max)	23–73	27–70	28–79	24–77
	Median	54	51	56.5	49.5

IR: internal rotation; ER: external rotation; SD: standard deviation

*p<0.05, **p<0.01

Table 3. The patterns of ipsilateral rotational range of motion in the different hip joints

Pattern	Total		Left side		Right side		
	Hip joints	%	Hip joints	%	Hip joints	%	
Total	IR≈ER	210	47.3	104	46.8	106	47.7
	IR>ER	66	14.9	27	12.2	39	17.6
	IR<ER	168	37.8	91	41.0	77	34.7
	Total	444	100	222	100	222	100
Male	IR≈ER	151	** 46.6	74	** 45.7	77	** 47.5
	IR>ER	22	** 6.8	7	** 4.3	15	** 9.3
	IR<ER	151	** 46.6	81	** 50.0	70	** 43.2
	Total	324	100	162	100	162	100
Female	IR≈ER	59	** 49.2	30	** 50.0	29	** 48.3
	IR>ER	44	** 36.7	20	** 33.3	24	** 40.0
	IR<ER	17	** 14.2	10	** 16.7	7	** 11.7
	Total	120	100.1	60	100	60	100

IR: internal rotation; ER: external rotation, **p<0.01

One-way repeated-measures ANOVA (Table 2) and the χ^2 test (Tables 3 and 4) were conducted using IBM SPSS Statistics (ver. 23). The study was approved by the International University of Health and Welfare Ethics Committee (13-Io-154-2). Prior to participation, the subjects were informed that they were free to withdraw during the examination or at the end of measurement without any consequences. Accordingly, the study content and purpose were clearly explained to the subjects who provided written and/or verbal approval prior to participation.

RESULTS

The mean, standard deviation, range (minimum–maximum), and median values of the internal rotation and external rotation of the hip joint on the right and left sides of the participants are presented in Table 2. The ROM of internal and external rotation of the left and right hip joints was found to significantly differ between the male and female subjects (Table 2).

The number of individuals exhibiting each pattern and the proportion of each pattern on the left and right side are shown in Table 3. The frequency of the patterns (IR \approx ER, IR $>$ ER, IR $<$ ER) on one side differed significantly according to gender (Table 3).

However, the patterns did not significantly differ between the left and right sides. The appearance rate and number of occurrences, along with the mean, standard deviation, and maximum value of the differences between internal and external rotation of the various patterns of ROM on the right and left sides are shown in Table 4.

The number of subjects exhibiting a combination of the nine patterns significantly differed according to gender (Table 4).

With regard to the combination pattern based on the differences between the internal and external rotation of the ipsilateral joint on the left and right sides, the appearance rate of the balanced type in both sides was approximately 30% in all subjects. In particular, among the male subjects, the appearance rate of the combination of the greater left internal rotation pattern and greater right external rotation pattern was 0.6%, and that of the combination of the greater left external rotation pattern and greater right internal rotation pattern was 2.5%. In contrast, the appearance rate of these two combination patterns was 0% in female subjects.

The appearance rates of the greater external rotation pattern and greater internal rotation pattern on both sides in male subjects were 31.5% and 1.2%, respectively. In contrast, the frequency of the greater external rotation pattern and greater internal rotation pattern on both sides in female subjects were 8.3% and 25%, respectively.

In male subjects, the average difference between internal and external rotation ROM patterns on the left and right sides was $>10^\circ$ and $<20^\circ$ in ten cases and $>20^\circ$ in two cases. In those two cases, the greater external rotation pattern was observed

Table 4. Combinations of the patterns of rotational range of motion patterns in ipsilateral hip joints and the difference between external and internal rotation

	Left	Right	n	%	Lt. IR-ER (°)		Rt. IR-ER (°)		
					mean \pm SD	Max	mean \pm SD	Max	
Male n=162		IR \approx ER	47	**	29.0	4.0 \pm 2.7	9	4.3 \pm 2.6	9
	IR \approx ER	IR $>$ ER	9	**	5.6	5.2 \pm 2.5	9	13.7 \pm 4.7	25
		IR $<$ ER	18	**	11.1	4.9 \pm 2.9	9	14.8 \pm 4.8	25
	IR $>$ ER	IR \approx ER	4	**	2.5	12.0 \pm 2.2	15	5.0 \pm 4.6	9
		IR $>$ ER	2	**	1.2	12.0 \pm 1.4	13	14.0 \pm 0.0	14
		IR $<$ ER	1		0.6	16.0 \pm 0.0	16	13.0 \pm 0.0	13
IR $<$ ER	IR \approx ER	26	**	16.0	16.9 \pm 6.1	36	4.5 \pm 3.0	9	
	IR $>$ ER	4		2.5	14.0 \pm 4.2	20	15.0 \pm 4.4	20	
	IR $<$ ER	51	**	31.5	25.8 \pm 11.6	56	22.6 \pm 9.4	50	
Female n=60		IR \approx ER	19	**	31.7	3.9 \pm 2.9	9	3.4 \pm 1.7	7
	IR \approx ER	IR $>$ ER	9	**	15.0	4.1 \pm 2.3	8	22.9 \pm 12.5	47
		IR $<$ ER	2	**	3.3	6.5 \pm 0.7	7	22.5 \pm 14.8	33
	IR $>$ ER	IR \approx ER	5	**	8.3	19.4 \pm 12.4	41	6.6 \pm 3.2	9
		IR $<$ ER	15	**	25.0	19.0 \pm 5.5	30	23.8 \pm 10.4	44
	IR $<$ ER	IR \approx ER	5	**	8.3	16.8 \pm 4.3	22	3.8 \pm 2.2	6
IR $>$ ER		0		0.0					
		IR $<$ ER	5	**	8.3	28.4 \pm 13.4	45	21.2 \pm 6.6	29

Lt.: left side; Rt.: right side; IR: internal rotation; ER: external rotation, **p<0.01

on both sides. In contrast, in female subjects, the average difference between internal and external rotation ROM patterns on the left and right sides was $>10^\circ$ and $<20^\circ$ in three cases and $>20^\circ$ in five cases. In male subjects, the maximum value of the difference between internal and external rotation was $>10^\circ$ and $<20^\circ$ in five cases and $\geq 20^\circ$ in seven cases; in female subjects, none of the cases showed a value of $>10^\circ$ and $<20^\circ$, although eight cases showed a value of $\geq 20^\circ$. Subjects classified with the greater external rotation type having a significant difference of $>50^\circ$ between internal and external rotation in the ipsilateral joint ROM were all male subjects. However, the group of subjects with a difference of 45° included a few female subjects. Among the subjects classified with the greater internal rotation pattern, one female subject had a maximum difference between external and internal rotation of $>30^\circ$, whereas this value was only 14° in a male subject.

DISCUSSION

In the present study, the ROM patterns of the ipsilateral hip joint were assessed and classified among healthy Japanese subjects, and the presence of asymmetric states between internal and external rotation in the ipsilateral hip joint, along with its distribution, was determined. Although the presence of hip rotation ROM patterns on both sides has been examined in the United States and Europe, the present study appears to be the first such study to be performed in Asia^{7, 11}). With regard to hip rotation ROM in healthy adults in Japan, external rotation was greater than internal rotation in male subjects, whereas internal rotation was greater than external rotation in female subjects. Such differences in the rotational ROM patterns of the ipsilateral hip joint clearly indicate variations between male and female subjects (Table 3). A total of 47.3% subjects showed a balanced pattern, where the difference between internal and external rotation was $<10^\circ$. The greater external rotation pattern and greater internal rotation pattern (i.e., unbalanced patterns) showed different trends between genders.

In particular, among male subjects, the greater external rotation pattern was observed in 46.6%, whereas the greater internal rotation pattern was observed in 6.8%. In other words, there was a trend towards the greater external rotation pattern in male subjects. In contrast, in female subjects, the greater internal rotation pattern was observed in 36.7% subjects, whereas the greater external rotation pattern was observed in 14.2% subjects, i.e., there was a trend towards the greater internal rotation pattern in female subjects. However, no significant difference in the ipsilateral hip rotation ROM patterns between the left and right sides was observed both in male and female subjects.

Based on these patterns, it could be noted that antagonizing contrasting patterns were linked between the left and right sides.

With regard to pattern classification, a trend towards the greater external rotation pattern was observed in male subjects and a trend towards the greater internal rotation pattern was noted in female subjects.

Lee Sang Wk et al.¹²) reported that the ROM of hip flexion and internal rotation is limited in cases where the lumbar region is unstable. Harris-Hayes, who assessed the strength of the hip external rotators in some hip postures, reported¹³) that individuals with unilateral chronic hip joint pain exhibited significant weakness in their uninvolved hip. Takemasa et al.¹⁴) described the relationship of the ROM between internal rotation and external rotation of the hip joint; the authors stated that one may be larger than normal, whereas the other one may be smaller than normal, which could result in an increase in ROM in one direction and decrease in ROM in the opposite direction. Subjects who exhibited a significant difference between internal and external rotation in the present study were considered to represent such cases.

The presence of an antagonistic relationship in the rotational ROM of the hip joint on both sides was confirmed in this study. When the left and right combination patterns were examined based on the difference between internal and external rotation ROM in the ipsilateral joint, the proportion of subjects with asymmetry in the rotational ROM of the hip was found to be approximately 70% (Table 4). Male subjects tended to have greater external rotation, whereas females tended to have greater internal rotation; these findings agree with those of Ellison et al⁶). Moreover, Tamari et al.¹⁵) reported that preventive exercises to maintain the internal rotation of the hip may be important for elderly male subjects to avoid knee deformities. In fact, Cibulka et al.¹⁶) mentioned that patellofemoral joint problems are the most commonly observed overuse injury of the lower extremity and that altered femoral or hip rotation may play a role in patellofemoral pain.

A significant difference between internal and external rotation can be considered to affect performance, including the control of posture and contractile function of the muscles. Hence, further assessments of the difference between internal and external rotation, as in the present study, could help prevent non-illness. The evaluation of asymmetry in hip rotation ROM in healthy individuals may be useful to determine such trends; this could then lead to the assessment of such findings in pathological conditions or in non-illness conditions such as in cases of musculoskeletal system disease.

However, asymmetry of the rotational ROM of the hip may likely be associated with problems in the adjacent joints. Hence, the pattern classification determined in the present study is expected to be useful in the evaluation of such conditions. For instance, in cases with inflammation of the involved joint and pain during the therapeutic approach, this classification pattern can be used as a basis to indicate the potential for approach from the uninvolved side rather than the involved side.

Manipulative therapy in physical therapy is expected to prevent non-illness and play a role in preventive medicine in the future. The findings of the present study can serve as a guide when considering the evaluation and approach towards asymmetry in the rotation ROM of the hip joint.

REFERENCES

- 1) Joshua C: (Takahara Y, Katou G): Chapter 1. The Reliability and Diagnostic Utility of the Orthopaedic Clinical Examination. In: Orthopaedic Clinical Examination: An Evidence Based Approach for Physical Therapists. Elsevier Japan, 2007, pp 2–20.
- 2) Nitta K: Dialogue with ahead sick. Tokyo: Bunka Sousaku Syuppan, 1996, pp 9–13.
- 3) Gatterman MI: Foundations of Chiropractic. Mosby, 1995, pp 6–9.
- 4) Kishi S, Morikita I: Range of motion of hip joints of male university kendo practitioners with lower back pain. *J Phys Ther Sci*, 2009, 21: 253–256. [[CrossRef](#)]
- 5) Uritani D, Fukumoto T: Differences of isometric internal and external hip rotation torques among three different hip flexion positions. *J Phys Ther Sci*, 2012, 24: 863–865. [[CrossRef](#)]
- 6) Ellison JB, Rose SJ, Sahrman SA: Patterns of hip rotation range of motion: a comparison between healthy subjects and patients with low back pain. *Phys Ther*, 1990, 70: 537–541. [[Medline](#)]
- 7) Cibulka MT, Strube MJ, Meier D, et al.: Symmetrical and asymmetrical hip rotation and its relationship to hip rotator muscle strength. *Clin Biomech (Bristol, Avon)*, 2010, 25: 56–62. [[Medline](#)] [[CrossRef](#)]
- 8) Murayama S, Ihashi K: Examination of laterality and measurement position of hip rotational ROM. *Touhoku-Rigakuryouhougaku*, 2003, (15): pp 31–35.
- 9) Han H, Kubo A, Kurosawa K, et al.: Hip rotation range of motion in sitting and prone positions in healthy Japanese adults. *J Phys Ther Sci*, 2015, 27: 441–445. [[Medline](#)] [[CrossRef](#)]
- 10) Yonemoto K, Ishigami S, Kondo T: The method guidelines for range of motion measurement. *Jpn J Rehabil Med*, 1995, 32: 207–217. [[CrossRef](#)]
- 11) Kouyoumdjian P, Coulomb R, Sanchez T, et al.: Clinical evaluation of hip joint rotation range of motion in adults. *Orthop Traumatol Surg Res*, 2012, 98: 17–23. [[Medline](#)] [[CrossRef](#)]
- 12) Lee SW, Kim SY: Comparison of chronic low-back pain patients hip range of motion with lumbar instability. *J Phys Ther Sci*, 2015, 27: 349–351. [[Medline](#)] [[CrossRef](#)]
- 13) Harris-Hayes M, Mueller MJ, Sahrman SA, et al.: Persons with chronic hip joint pain exhibit reduced hip muscle strength. *J Orthop Sports Phys Ther*, 2014, 44: 890–898. [[Medline](#)] [[CrossRef](#)]
- 14) Takemasa S, Shimada T, Hidaka M: Normal range of motion of joints in the aged people. *Kobe Daigaku Igakubu Hokengakka Kiyo*, 1997, 13: 77–82.
- 15) Tamari K, Tinley P, Aoyagi K: Gender and age-related differences in axial alignment of the lower limb among healthy Japanese volunteers: comparative and correlation study. *J Jpn Phys Ther Assoc*, 2003, 6: 25–34. [[Medline](#)] [[CrossRef](#)]
- 16) Cibulka MT, Threlkeld-Watkins J: Patellofemoral pain and asymmetrical hip rotation. *Phys Ther*, 2005, 85: 1201–1207. [[Medline](#)]