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Differences of Isometric Internal and External Hip Rotation Torques among Three Different Hip Flexion Positions

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Abstract. [Purpose] The aim of this study was to investigate isometric internal and external rotation torques of the hip at three different flexed positions of the hip. [Subjects] Twenty healthy university students. [Methods] Isometric internal and external maximum rotation torques of the hip on both sides were measured using a torque machine in the recumbent, semi-recumbent and sitting positions. Dependent variables were the isometric internal and external rotation peak torques of the hip. Independent variables were the three testing positions and each side. Measured data were analyzed using two-way analysis of variance with a post-hoc test. [Results] Mean isometric internal rotation torque was significantly higher in the sitting position than in the recumbent or semi-recumbent positions. Torque was also significantly higher in the semi-recumbent position than in the recumbent position. No interaction between testing position and leg side was found. Regarding isometric external rotation, no interaction or main effects were found among the three positions. [Conclusion] Isometric hip internal rotation torque significantly increased as the hip flexed; however, external rotation did not change significantly.

Key words: Hip, Rotation torque, Flexion angle

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INTRODUCTION

In the anatomical position, the primary external rotators of the hip are the gluteus maximus and 5 of the 6 short external rotators. There are no primary hip internal rotators[1)], because the internal rotation moment arm (MA) is significantly shorter than the external rotation MA[2)]. Although the muscles stated above serve as hip external rotators in the anatomical position, the actions of muscles around the hip depend on hip position in other positions[1, 3)]. Therefore, attention should be given to hip position to clarify which muscles serve as movers in specific directions when measuring muscle strength of the hip. While hip rotation torque has been suggested to change with position, actual differences in hip rotation torques between rotator groups at any given point within the range of the sagittal plane motion are not currently known. Although one isokinetic study reported hip rotation torques at 0° and 90° of flexion, changes within that range were not clear[4)].

The purpose of this study was thus to investigate isometric internal and external rotation torques of the hip at three different flexed positions of the hip, the sitting, semi-recumbent and recumbent positions.

SUBJECTS AND METHODS

The participants were 20 young healthy volunteers (6 men, 14 women) with a mean age of 21.6 (SD 1.0) years. Participant characteristics are presented in Table 1. Inclusion criteria were individuals with no previous history of serious hip, knee or ankle injury, and no pain in these joints at the time of testing. Written informed consent was obtained from each participant before the study began. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board for Human Research of Kio University.

Isometric hip rotation torques were measured using a torque machine (System 3; Biodex Medical Systems, New York, USA). Torque was measured in three testing positions based on the inclination angle of the backrest of the torque machine: 10°, recumbent position; 55°, semi-recumbent position; and 85°, sitting position. The inclination angles of the backrest of the torque machine are 10, 25, 40, 55, 70 and 85 degrees. We selected the minimum, medium and maximum angles as measurement positions. Participants were required to sit on the seat of the torque machine facing the dynamometer with the knee flexed at 90°. The axis of the

Table 1. Descriptive characteristics

Sex (n)	Male, 6; Female, 14
Age (years)	21.6 (1.0)
Height (cm)	165.0 (7.2)
Weight (kg)	60.3 (7.2)
Dominant leg side (n)	Right, 14; Left, 6

Age, height and weight are expressed as mean (standard deviation).

Table 2. Maximal torques of the internal and external rotation of the hip

	Internal rotation			External rotation		
	Recum	Semi-recum	Sitting	Recum	Semi -recum	Sitting
Dominant	25.4 (6.0)	35.8 (6.2)††	39.2 (7.9)††,‡	36.6 (16.0)	42.8 (16.8)	43.9 (14.7)
Non-dominant	25.0 (6.7)	35.1 (7.3)††	39.6 (9.3)††,‡	36.4 (13.8)	41.2 (12.1)	42.9 (13.2)
Average	25.2 (6.3)	35.5 (6.7)††	39.4(8.5)††,‡	36.5 (14.7)	42.0 (14.5)	43.4 (13.8)

All data are expressed as the mean (standard deviation) Nm. Recum: Recumbent position; Semi-recum: Semi-recumbent position. ††vs recumbent, p<0.01. ‡vs semi-recumbent, p<0.05.

dynamometer was aligned with long axis of the femur. The back of each knee was positioned at the anterior border of the seat. The thigh on the testing side, the pelvis and chest were stabilized with strap belts. The padded dynamometer arm was attached immediately above the medial malleolus of the lower leg. Hand-grips were used to stabilize the upper limbs.

Lower-limb dominance was determined by asking each subject to kick a ball with the leg that felt most natural. Participants were required to repeat three consecutive 5-s maximal isometric internal or external rotations of the hip with a 5-s rest between each exertion. Then after a 3 minute rest interval, the subjects repeated this same procedure for the opposite (internal or external) rotation. After completing both internal and external rotation measurements on one limb, the procedure was repeated for the opposite limb. The other two testing positions were measured in the same way, with a 5-minute rest interval between positions. The first measuring side and the first measuring position were chosen randomly and we also randomized the other testing positions after the first position. Participants practiced testing procedures 1 day before their actual measurement.

Outcome measures were the isometric maximum internal and external rotation torques. Maximum torque of the three trials in each setting were analyzed using two-way analysis of variance with Tukey's multiple comparisons test. Dependent variables were internal and external peak torque. Independent variables were the testing position and leg side. Values of $p<0.05$ were considered statistically significant. All data were analyzed using SPSS for Windows version 14.0 J (SPSS Japan, Tokyo, Japan).

RESULTS

The results are presented in Table 2. With regard to internal rotation, a main effect was found only for testing position (F (2,114) = 39.89, $p<0.01$). Mean isometric internal rotation torque was significantly higher in the sitting position (dominant foot: 39.2 ± 7.9 Nm; non-dominant foot: 39.6 ± 9.3 Nm; mean of both sides: 39.4 ± 8.5 Nm) than in the recumbent position (25.4 ± 6.0 Nm, 25.0 ± 6.7 Nm, 25.2 ± 6.3 Nm, respectively; all $p<0.01$) or the semi-recumbent position (35.8 ± 6.2 Nm, 35.1 ± 7.3 Nm, 35.5 ± 6.7 Nm, respectively; all $p<0.05$). Torque was also significantly higher in the semi-recumbent position than in the recumbent position ($p<0.01$). No interaction between the testing position and leg side was found.

With regard to isometric external rotation, no interaction or main effects were found among the recumbent position (36.6 ± 16.0 Nm, 36.4 ± 13.8 Nm, 36.5 ± 14.7 Nm, respectively), the semi-recumbent position (42.8 ± 16.8 Nm, 41.2 ± 12.1 Nm, 42.0 ± 14.5 Nm, respectively) or the sitting position (43.9 ± 14.7 Nm, 42.9 ± 13.2 Nm, 43.4 ± 13.8 Nm, respectively).

DISCUSSION

In this study, isometric internal rotation torque of the hip only increased significantly with hip flexion, irrespective of leg side. This finding might result from the increase in MA of the internal rotators and reversal of the rotary action of some of the external rotators[1]. Dostal et al.[5] reported that although there are no primary or assistant hip internal rotators in the anatomical position, the anterior and middle fibers of the gluteus medius and minimus muscles work as hip internal rotators at 40° of hip flexion. In addition, posterior fibers of the gluteus medius and minimus and piriformis muscles also work as hip internal rotators at 90° of hip flexion. Delp et al.[2] reported that the anterior fibers of the gluteus maximus appear to switch the rotatory action toward internal rotation at around 45° of flexion, while the same fibers display an overall external rotation MA in the anatomical position, and MA of middle and posterior fibers of the gluteus maximus decrease with hip flexion. They also reported that internal rotation MA of the anterior fibers of the gluteus medius increases as the hip flexes, and that our result of that of the posterior fibers of the gluteus medius switches from external to internal rotator at around 45° of flexion[2]. Increased isometric internal rotation torque with flexion may be explained by these findings.

Isometric hip external rotation torque also increased as the hip was flexed, although no significant changes were found. If muscle action converts from external to internal rotation as the hip flexes, hip external rotation torque should theoretically decrease. The results of this study might have been derived from the effect of changes in muscle force. Torque was calculated based on MA and muscle force. Total force generated by the muscle represents the sum of active force and passive tension from the muscle. Total force is enhanced if the muscle is stretched to an appropriate length[6]. While MA of hip external rotators decreases as the hip flexes, hip external rotators are elongated to efficient lengths, allowing stronger contractions to develop[4].

Although previous studies have measured isokinetic hip rotation torque[4, 7], we measured isometric hip rotation torque in order to incorporate the results of cadaver studies[2, 5] that have reported MA of the hip at any given position into the clinical setting. Also, our results could be incorporated into the interpretation of outcomes of manual muscle testing by the brake test. Manual muscle testing (MMT) has generally been used to test the muscle strength of the hip in clinical settings. The hip joint is tested in the sitting position, that is, at 90° of hip flexion. In Hislop and Montgomery's popular clinical textbook, which is used to teach MMT, it is noted that muscle strength of the external rotators of the hip, comprising the short external rotators and posterior fibers of the gluteus maximus, can be measured at 90° of hip flexion[8]. However, considering that the actions of the muscles around the hip change depending on its position, manual muscle testing of hip rotation in the sitting position might not measure muscle strength as described in the textbook.

A first limitation of this study was the restricted testing positions. Measurements were only made in three positions. The hip flexion angle was controlled by inclination of the backrest on the torque machine and was not measured directly in this study. In addition, isometric hip internal and external rotation were performed at only one rotation angle. Further research is required in various settings to clarify the relationships between hip rotation torque and hip position. A second limitation was that the unfamiliar testing positions used in this study might have exerted an influence on the results. In the recumbent position, maximal efforts to rotate the hip might have been difficult for the participants because they were unfamiliar with exerting hip rotation in this position.

In conclusion, isometric hip internal rotation torque significantly increased as the hip flexed; however, external rotation did not change significantly. Our results suggest that attention should be given to hip position to clarify which muscles serve as movers in specific directions when measuring muscle strength of the hip.

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