



Original Article

The ratio of medial and lateral hamstring muscle thickness does not correlate with the lateral tibial rotation angle in the standing position in healthy young adults

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Abstract. [Purpose] To investigate the relationship between the lateral tibial rotation angle during knee joint flexion and the medial and lateral hamstring muscle thickness ratio during knee joint extension while resting, doing nothing, in upright standing position. The lateral tibial torsion is an important factor of orthopedic knee joint diseases as well as other weight bearing joint diseases such as osteoarthritis, meniscus syndrome, anterior cruciate ligament rupture, etc. [Subjects and Methods] Thirty healthy young adults participated in this study. The thickness of the medial and lateral hamstrings was measured using ultrasonographic imaging technique during knee extension in a resting position. The angle of tibial rotation was measured with 2D motion analysis during knee flexion in a half kneeling position. Pearson's correlation coefficient was used to test the relationship. [Results] There is no significant relationship between the angle of lateral tibial rotation and the ratio of hamstring muscle thickness. [Conclusion] These results demonstrate that lateral tibial rotation is not affected by hamstrings during rest in a standing position.

Key words: Hamstrings, Sonograph, Tibial rotation

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INTRODUCTION

The knee joint is the largest and most complicated joint which acts as a major weight bearing joint involved in walking, stepping, and running. Normally, the knee joint supports 4–6 times the body weight during gait and decreases energy consumption by reducing vertical and lateral movements from the body center^{1, 2)}. However, tissue injury can occur in the knee joint if excess range of motion or abnormal movement is made³⁾. The femoral bone connected to the tibia plays an important role in the longitudinal axis of the lower limb which is related to the tibial rotation angle⁴⁾. Furthermore, disabled tibial rotation induces osteoarthritis and musculoskeletal imbalance following the change of compression and rotation force with abnormal femoral movement^{5, 6)}.

The hamstring muscle consists of the semimembranosus and semitendinosus muscles in the medial part and the short and long head of the biceps femoris muscle in the lateral part that have a function in a medial and lateral tibial rotation, respectively⁷⁾. Also, the hamstring muscle contributes to the stability and sagittal and transverse plane movement of the

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knee⁸). While changing the length of the muscle fibers and tendons has an effect on the hamstring strength, abnormal gait and exercise can also cause pain or muscle imbalance, which in turn can change body posture. The anatomical cross-sectional area and the thickness of the muscle are well known parameters of functional capacity measurement that have an effect during resistance exercises⁹. In a previous study it was shown that there is a strong relationship between the hamstring thickness measured using ultrasound imaging and the cross-section area at the 50–70% region of thigh length examined using magnetic resonance imaging (MRI)¹⁰. Thus, the study of leg muscle contraction changes using ultrasound imaging has a beneficial clinical meaning.

Several studies indicated that muscle imbalance between the medial and lateral hamstring contributes to lateral rotation of the tibial bone while standing¹¹). However, correlation between the tibial torsion angle and the ratio of hamstring thickness has not been investigated in previous studies. Therefore, the purpose of this study was to investigate the correlation between the tibial torsion angle and the thickness ratio of the medial and lateral hamstring muscle to provide a clinical guideline.

SUBJECTS AND METHODS

Thirty male students of “B” university located in in Cheonan, Korea, were recruited for this study. All participants received verbal descriptions of the study procedures and signed consent forms indicating agreement to participate in the study. Participants with orthopedic disorders of lower limbs, drug ingestion, surgeries of lower limbs, and neurological leg problems were excluded (Table 1). All experimental procedures were approved by the Institutional Review Board (Approval number: BUIRB-201606-HR-011).

This study used the ultrasonography device LOGIQ P6 PRO (LOGIQ P6 PRO, GE Inc., Wisconsin, USA) to measure thickness of the biceps femoris muscle. Scanning mode was B-mode, depth was 6 cm, frequency was 4 MHz, and a linear probe was used. The inner caliper was used for the thickness measurement. Measurements were repeated three times. Marker and stickers were used to correctly find the same spot.

The participants’ lengths of greater trochanter and lateral epicondyle of the thigh were determined with tape measures to ascertain the location of the biceps femoris (BF), semimembranosus (SM) and semitendinosus (ST) in a prone position (Komeron corp., Korea). From the great trochanter of 60% spot, a vertical line was drawn using a marker pen. Subjects had their knee flexed while the experimenter located the biceps femoris tendon around the popliteal region. The experimenter found the crossing point between the vertical line and the biceps femoris tendon, and then a sticker was attached. In the same way, semimembranosus tendon inserts on medial popliteal line and origins from ischial tuberosity of femur were located. Experimenter also found the crossing point using the same method (described above) and attached a sticker. Measurements of hamstring thickness were done at the sticker sites in position of subjects which had maintained body alignment in standing position, not another movement¹⁰).

Methods of tibial torsion angle included transmalleolar axis (TMA) and thigh foot angle (TFA). Commonly, TMA method has a higher reliability of 0.91 than TFA method¹²). The TMA method measures the average angle between the parallel line of femoral bone and the vertical line of connected line of lateral and medial malleolus at the foot. The data were obtained from the left and right side of the legs with an average value of 3 repeated measures for higher intra-rater reliability. The tibial torsion angle between vertical line and parallel line of femur was measured using Image J program (National Institutes of Health, USA).

Statistical analysis was performed using SPSS 18.0 (SPSS Inc., Chicago, USA). To compare correlation changes, Pearson correlation coefficient was used to measure the average values between the two variables expressed as percentage of muscle thickness (BF thickness/ST+ SM thickness, BF thickness/ST thickness, BF thickness/SM thickness) and tibial torsion angle. The significance level was set at $p < 0.05$.

RESULTS

There was no correlation between the right and left tibial torsion angle and ST+SM thickness divided into BF thickness. Additionally, it did not correlate with BF thickness/ST thickness and BF thickness/SM thickness when compared to the right and left tibial torsion angle (Table 2).

Table 1. General characteristics of the participants (n=30)

Age (yrs)	Height (cm)	Weight (kg)
22.3 ± 2.3*	173.2 ± 5.9	65.1 ± 11.4

*Values are expressed as mean ± standard deviation (SD)

Table 2. Pearson’s correlation values between the hamstring and tibial rotation on the right and left sides

	BF/(SM+ST)	BF/SM	BF/ST
L.TA	0.063	0.157	-0.99
R.TA	-0.018	-0.032	0.012

BF: biceps femoris; SM: semimembranosus; ST: semitendinosus; R.TA: right torsion angle; L.TA: left torsion angle
Values are expressed as mean ± standard deviation (SD).

DISCUSSION

In this study, we examined whether the ratio of the medial and lateral hamstring thickness correlates with the tibial torsion angle. We used three percentage values of the biceps femoris, semimembranosus, and semitendinosus thickness in the thigh and the tibial torsion angles obtained using ultrasonography. We found that there is no correlation between the three variables of the right and left legs and tibial torsion angle.

Guelich et al. previously studied degrees of freedom of the tibio-femoral movement in seven cadavers by looking at the independent muscle load of the medial and lateral hamstring following anterior cruciate ligament injury. They revealed that selective strength exercise for the medial and lateral hamstring is needed to reduce the anterior cruciate ligament injury; furthermore, rehabilitation after injury is required because the medial and lateral hamstring contributes to tibial rotation¹³). With regard to the selective hamstring atrophy generation by muscle injury or anterior cruciate ligament reconstruction, lateral hamstring affects the knee flexor activity and tibial rotation when measuring isokinetic strength of a 40° knee flexion in normal young subjects¹⁴). Similarly, imbalance of the medial and lateral hamstring activity correlates with tibial rotation in a standing position with knees flexed to 90° in healthy adult male and female subjects¹⁴). These reports show that the medial and lateral hamstring contractions affect tibial rotation in the limb with the cruciate ligament injury and a movement-recruited contraction. However, correlation between the medial and lateral hamstring and tibial rotation has never been investigated in a position accompanied by knee flexion using ultrasonography in normal subjects.

The main reason for low correlation of the medial and lateral hamstring and tibial rotation is the fact that the tibial torsion angle is influenced by many variables. The movement of the knee joint depends on both the passive movement of the bone and ligament and the active muscle load¹⁵). Also, many structures connecting to the hamstring affect the tibial torsion angle. Especially, the screw-home mechanism of the extended tibial bone is about a 20° lateral rotation in a fixed femur. This movement generates the end point for the extension and rotation of the knee. The screw-home mechanism is affected by the medial femoral condyle shape, passive tension of the anterior cruciate ligament (ACL), and the medial and lateral meniscus, which has a larger space than the medial meniscus located in tibiofemoral joint¹⁶). When the knee is flexed at 90°, these structures are influenced by the tibial torsion angle which depends on the length of the ACL, shape of the bone, and meniscus. The lateral tibial torsion angle increases in the presence of structural deformity of the pelvic and ankle joint and the external rotator weakness of the pelvic joint⁶). Also, it directly affects knee stability by altering the torsion angle of two-joint muscles (e.g. gastrocnemius) and popliteal structures. It might be because the tibial torsion angle is related to arthrokinematics of these structures and soft tissues.

Measurements were only made in participants that were in a static standing position and did not have enough hamstring contractions of the knee flexion. Further studies should be done to assess the static posture following knee flexion with excessive hamstring contractions and to assess dynamic posture changes resulting from knee extension and flexion without the movement of other structures. Also, the patients with arthritis and ACL injury accompany with hamstring weakness could be done to study the correlation between tibial rotation and hamstring thickness in upright standing position. We conclude that the hamstring thickness in a static standing position does not correlate with the tibial torsion angle during ultrasound imaging evaluation of normal young subjects. This study evaluated the correlation between the tibial torsion angle and ratios of the medial and lateral hamstring muscle thickness in a resting position. It did not show a significant correlation. These results indicate that muscle contraction in a standing position does not affect the tibial torsion angle in normal young adults.

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