Original Article

Relationship between single-leg stance test with light touch and hip muscle strength in healthy young adults

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Abstract. [Purpose] This study investigated the relationship between the single-leg stance test with light touch and hip rotator muscle strength. [Participants and Methods] Thirty-one healthy young adults participated in the study. A single leg stance test with light touch was performed to evaluate the participants’ static balance ability. The duration that an individual could successfully perform the single leg stance test with light touch in the eyes open was measured. The participants were instructed to slightly touch their right index fingertip on the digital scale. The hip muscle strength of the internal rotators and external rotators were measured by the isometric peak torque. The internal/external rotator strength ratio was calculated by dividing the strength of the internal rotator by that of the external rotator. [Results] The hip external rotator muscle strength was higher in males than in females. Moreover, there was a significant correlation between the single-leg stance test with light touch and hip external rotator muscle strength in males and between the single leg stance test with light touch and hip internal rotator muscle strength in females. Furthermore, a significant positive correlation was found between the single leg stance test with light touch and hip internal rotator/external rotator ratio in males. [Conclusion] We concluded that the single leg stance test with light touch is a useful tool to evaluate static hip muscle strength.

Key words: Hip rotator cuff, Hip stability, LT-SLST

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INTRODUCTION

The stability of the hip to maintain posture is functionally important for the hip external rotators (ERs), which are considered the rotator cuff of the hip joint. The ERs are functionally important muscles that significantly contribute to hip joint stability. The decreased stability of the hip joint may lead to an increase in femoral translation, greater joint contact pressures, and ultimately to degenerative hip pathology. Chronic hip joint pain (CHJP) is also referred to as prearthritic hip disease or intra-articular hip disease. Young adults with CHJP may have weakness in the hip rotators and abductors. Furthermore, mild-to-moderate hip osteoarthritis (OA) is related to a significantly lower hip flexor, extensor, and abductor strength compared with healthy controls, having a significantly lower volume of the adductor, gluteus maximus and gluteus minimus muscles, but not gluteus medius muscles. Therefore, the assessment of hip stability in standing is important for the prevention of the hip joint disease.

During single-leg stance (SLS), the muscles of the supporting lower limb have to exert large amounts of force and contribute to postural control in order to maintain a stable posture. Lower extremity disorders may decrease the lower limb strength or balance ability, making it extremely difficult or even impossible to perform SLS for a long time. In clinical prac-
tice, SLS has been used to evaluate static balance ability. Thus, the SLS test is recommended as a highly reliable test with an acceptable measurement error for assessing standing balance in patients with hip OA. However, the ability to maintain SLS is attributed to multiple lower extremity muscles. The SLS test was found to be correlated with the strength of the gluteus medius, the quadriceps, the hamstrings, and the plantar flexors. On the other hand, SLS was affected by somatosensory information. In this context, previous studies reported that SLS was affected by vibration and tactile sensitivity and that the triceps surae muscles could alter the perception of the ankle joint position. Moreover, it has been indicated that the lack of proprioceptive information in hip OA patients leads to a loss of neuromuscular control. It is believed that the SLS test for hip stability assessment adjusts for the effect of lower extremity muscle activity and somatosensory perception.

The light touch (LT) contact of an index fingertip with a stationary surface can provide information about the external space due to somatosensory perception. Previous studies reported that LT with SLS (LT-SLS) decreased body sway, and the gastrocnemius and the anterior tibial muscles had little electromyography (EMG) activity. In fact, there is a possibility that LT-SLS can be used for the stability assessment of the hip with adjusted somatosensory perception. We hypothesized that LT-SLS could contribute to the detection of hip instability due to hip rotator muscle weakness in clinical physical therapy. Therefore, we investigated the relationship between LT-SLS and the hip rotator muscle strength. In addition, previous studies reported that females, compared with males, demonstrated lower extremity alignment measures in SLS. Therefore, the role of hip rotator muscles in hip stability may be gender specific. Hence, in our study, the relationship between LT-SLS and hip rotator muscle strength was separately analyzed for both males and females.

PARTICIPANTS AND METHODS

Thirty-one healthy young adults (15 males, 16 females) with a mean age of 21.3 ± 0.7 years respectively, participated in the study. The participants received a detailed explanation of the study procedure, and all the participants signed the written informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the institutional review board of the International University of Health and Welfare (16-Ifh-042). The exclusion criteria in the volunteers included the presence of any musculoskeletal, neurological, or cardiopulmonary problems or whose hip rotator strength was insufficient to comply with the instructions of the experiment procedure.

In this study, a LT-SLS test was conducted to evaluate the participants’ static balance ability. The time that an individual can stand in the LT-SLS test with eyes open was measured, and two trials were performed. The best of the two trials was recorded as the LT-SLST (LT-SLS) time. The participants were instructed to place their left hand on their iliac crest, and slightly touch their right index fingertip on the digital scale (DS2006; Aska Co. Aichi, Japan) during LT (contact force <1 N) with the pelvis maintained in a horizontal position on a 20 cm platform. The LT-SLS was measured until the stance foot shifted, the lifted foot was placed back on the floor, or the LT contact force increased to ≥1 N. The participants were instructed to gaze at a fixed point for measurement.

The hip muscle strength of the internal rotators (IRs) and the ERs was measured by the isometric peak torque (N) using a handheld dynamometer (μ-Tas F1; Anima Co. Tokyo, Japan). The measurement position for hip IRs and ERs strength was similar to the hip rotation manual muscle testing procedure. The contact point of the dynamometer was 1 cm proximal to the medial and lateral malleolus. The participants were asked to push as hard as they could into the padded dynamometer for 5 seconds. The hip IRs and the ERs muscle strength values were expressed as the measured muscle strength divided by body weight and shin length (N/kgm). The shin length from the fibular head to the lateral malleolus was measured using tape in the supine position. The balance between the hip rotators muscle strength was indicated by the IR/ER ratio, which was calculated by dividing the IRs muscle strength with ERs muscle strength.

All the analyses were conducted using SPSS (ver. 25.0; IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was used to confirm that the data were distributed normally. The Spearman’s rank correlation coefficient was used to determine the relationship between the LT-SLST and the hip rotator muscle strength. The independent t-test was used to examine the differences in basic characteristics between the male and the female groups, whereas the Mann-Whitney U test was used to examine the differences in the LT-SLST and hip rotator muscle strength between the male and female groups. The significance level was set as p<0.05.

RESULTS

Table 1 shows the basic statistics and results of the independent t-test. The height, weight, body mass index and shin length showed significantly larger values in females than in males (Table 1). Table 2 demonstrates the LT-SLST, hip rotators muscle strength, and the results obtained by the Mann-Whitney U test. The results listed in Table 2 indicate that the hip ER muscle strength was higher in males than in females (Table 2).

The obtained results showed that a significant correlation exists between the LT-SLST and hip ER muscle strength in males (r=0.626, p=0.013) and between the LT-SLST and hip IRs muscle strength in females (r=0.518, p=0.031). Furthermore, a significant positive correlation was found between the LT-SLST and IR/ER ratio in males (r=0.725, p=0.005) (Table 3).
DISCUSSION

The results of this study indicated that the LT-SLST positively correlated with hip ER muscle strength \((r=0.626, p=0.013)\) and IR/ER ratio \((r=0.725, p=0.005)\) in males and with hip IRs muscle strength \((r=0.518, p=0.031)\) in females.

In a previous study of the relationship between hip rotator muscles and balance ability, the IR/ER ratio significantly correlated with dynamic SLS balance\(^{15}\). There was no observed correlation between the static SLS and IR/ER ratio. The results of our study were different from those of the previous study. In the present study, the LT-SLST was measured using the information of the external space provided by LT\(^{16}\). Another previous study reported that the LT-SLST was responsible for decreasing body sway and lower leg muscle activity\(^{10}\). In addition, LT significantly increased hip postural tone during standing, indicating that the increases in the hip postural tone were associated with a reduction in the postural sway\(^{17}\). This indicates that maintaining SLS was possible due to the hip rotator muscle strength and LT. Thus, this study suggests that the LT-SLST can be used as an index to evaluate hip stability associated with hip rotator muscle strength.

The relationship between the LT-SLST and the hip rotators muscle strength was different between males and females. The LT-SLST was moderately correlated with the ERs muscle strength, highly positively correlated with the IR/ER ratio in males, and moderately positively correlated with the IRs muscle strength in females. In addition, the hip ERs muscle strength was significantly greater in males than in females. In a previous study, the hip ERs strength has been reported to contribute to hip joint stability\(^{13}\). Therefore, the ERs strength of the hip may be correlated with LT-SLST in males. However, the LT-SLST has a higher positive correlation with the IR/ER ratio than the ERs muscle strength in males. Imbalance in the IR/ER ratio has been reported to decrease the range of the pelvic rotation motion in SLS, with cutoff values of <0.8 and >1.2\(^{15}\). In this study, the IR/ER ratio of males implied an imbalance at a value of 0.72, indicating that IRs muscle strength relative to the hip ERs
muscle strength is necessary to maintain SLS. The IR/ER ratio of the female participants was balanced at 0.94, indicating that the hip IRs muscle strength is necessary to maintain SLS. In a previous study involving EMG, muscle activity during isometric contraction of the vastus medialis was comparable for abduction and IRs in the anterior and in the middle part of the vastus medialis\(^{18}\). This suggests that the hip abduction and IRs torque of the gluteus medius enhance hip stability\(^{18}\). A previous study reported that females, compared with males, demonstrated larger quadriceps angles, more pronounced genu recurvatum and femoral anteverision, and greater anterior pelvic tilt\(^{14}\). However, this has not yet been elucidated in the present study, and therefore needs to be addressed in future studies. The results of this study suggest that the LT-SLS can be used to evaluate the periarticular hip muscles involved in hip stabilization.

One of the limitations of this study is that the LT-SLST needs to be examined for the reliability and reproducibility. The sustained contraction of the IRs and ERs of the hip is necessary for posture maintenance in the LT-SLS. Additionally, it is necessary to evaluate postural alignment during SLS for assessing the IR/ER ratio imbalance. Further studies should focus on investigating how LT-SLST can be used in clinical practice.

In this study, the relationship between LT-SLST and hip IR and ER muscle strength was investigated, aiming to establish a method to evaluate hip muscle function under load. The results showed that the LT-SLST was significantly correlated with the hip ER strength and IR/ER ratio in males and with the IR muscle strength in females. This study suggests that the LT-SLST is useful for the evaluation of static hip muscle function.

Conflict of interest
There is no conflict of interest.

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