Original Research

Hip Rotator Strength in Healthy Young Adults Measured in Hip Flexion and Extension by Using a Hand-held Dynamometer

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Objective: To investigate the effect of hip joint position on hip rotator muscle strength of healthy young adults by using a hand-held dynamometer.
Design: A cross-sectional cohort study.
Setting: A university medical center.
Participants: Thirty-four healthy (19 women, 15 men; mean [standard deviation] age, 25 ± 2.3 years) participated in this study.
Methods: A hand-held dynamometer was used to measure the strength of hip internal rotators and external rotators in 2 positions: hip flexion in sitting and hip extension in supine. The hip was tested in a neutral position with respect to rotation, abduction, and adduction. Isometric force in pounds was measured as the subject pushed against the device.
Main Outcome Measurements: For each subject, hip rotator muscle strength measurements were taken during a single session. Hypotheses were developed before data collection.
Results: Hip internal rotators were significantly stronger in hip flexion compared with hip extension ($P < .01$). There was no significant difference found in the hip external rotators between the 2 positions.
Conclusions: Hip internal rotators and external rotators behave differently when comparing strength measurements between the positions of hip flexion and hip extension. A hand-held dynamometer provided an objective measurement of strength that was clinically feasible to use. Both muscle length and moment arms influence force production of the hip rotators as the hip position changes. Understanding these relationships may help clinicians interpret strength findings and direct intervention toward strengthening the appropriate muscles by using the most advantageous position.

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INTRODUCTION

Physical therapists must have a comprehensive understanding of the anatomy and kinesiology of the hip to skillfully examine movement in healthy individuals and those with lower quarter pain syndromes. Muscle strength is an important factor that contributes to movement and needs to be carefully considered when examining the hip. In particular, the strength of the hip rotators, specifically the gluteal muscles and the deep external rotators (ER), contribute to precise control and stability of the hip during a variety of functional activities [1,2]. During gait, for example, the ERs of the stance limb on the right act to control counterclockwise pelvic rotation and internal rotation of the right femur. Also, the internal rotators (IRs) of the stance limb on the right act to rotate the pelvis clockwise, thus assisting with swing of the left limb [2].

Measurements of hip muscle strength are influenced by factors such as moment arms and muscle length, which can vary, depending on the hip joint position [3-6]. Muscles that control hip rotation are an excellent example of the influence of these factors on muscle strength. Based on data from muscle modeling studies, moment arms for hip rotator

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muscles vary between positions of hip flexion (HF) and hip extension (HE) [4,5]. Specifically, components of the gluteus maximus, medius, and minimus as well as the piriformis switch from having external rotation moment arms in HE to internal rotation moment arms in HF. Most of the deep ERs, such as the quadratus femoris and obturators, continue to have external rotation moment arms throughout the range of HF from 0°-90° [4]. These findings would lead the clinician to expect strength measurements for hip IRs to be stronger when the subject is tested in sitting with the hip flexed because of the increased contribution of the gluteal muscles. In contrast, one would expect the strength of hip ERs to be diminished in sitting due to the decreased contribution of the gluteal muscles.

Only a few investigators have examined the relationship between hip position and hip rotator muscle strength in healthy human subjects [6-8]. Jarvis [8] used an electronic instrument to measure isometric hip rotator torque in sitting (HF) and supine (HE), with the hip in 2 positions of rotation (end range and near neutral). Lindsay et al [6] examined peak torque of hip rotation throughout the range by using an isokinetic dynamometer in sitting (HF) with the knee flexed and in supine (HE) with the knee flexed and extended. Johnson and Hoffman [7] examined isometric hip rotation torque by using an isokinetic dynamometer. The hip was placed in neutral hip rotation and tested in 3 positions: sitting in 90° HF, semireclined in 40° HF, and supine (HE). The electronic instrument used by Jarvis [8] was not referenced or described; therefore, it cannot be replicated. The use of an isokinetic dynamometer in the more recent studies by Lindsay et al [6] and Johnson and Hoffman [7] are useful tools for research but may not be available or feasible to use in many clinical settings. An alternative device that may be more feasible for clinicians to use is a hand-held dynamometer. The hand-held dynamometer has been used successfully to assess muscle strength in a variety of populations [9-11].

Although the methods and instrumentation varied among the 3 studies, all investigators reported similar findings for the strength of the hip IRs [6-8]. Torque values for the IRs were significantly stronger when tested in HF compared with HE, thus supporting the muscle modeling theory. In contrast, results among the same studies varied for the strength of the hip ERs. Jarvis [8] and Johnson and Hoffman [7] found no significant difference in the torque values for the hip ERs between positions. Lindsay et al [6], however, found that peak torque for the ERs was significantly stronger in the hip flexed position. These findings are in contrast to what would be predicted from the muscle modeling theory discussed previously. Therefore, other mechanisms need to be considered to explain the change in external rotation muscle strength between positions. When discussing these findings, Lindsay et al [6] suggested that a mechanism related to muscle length may have influenced the torque-generating properties of the deep ERs. The hip flexed position may place these muscles in a more optimal length, closer to their peak on the length tension curve, thereby potentially improving the strength of the contraction [12,13]. Although not mentioned by Lindsay et al [6], one could also consider the impact of a length change in portions of the gluteus maximus when the hip is positioned in HF. These muscles, acting as hip IRs, also may be placed at a more optimal length for force production.

Overall, there is minimal evidence for the effect of position on either hip IR or ER strength in healthy human subjects, especially when using a simple clinical tool. Therefore, the purpose of this study was to compare hip rotator muscle strength in the position of HF to HE in healthy young adults by using a hand-held dynamometer. We hypothesized that (1) the hip IRs would be significantly stronger when tested in HF versus HE, and (2) there would be no significant difference for the ERs between positions.

METHODS

Institutional review board approval at Washington University School of Medicine was obtained before the study was conducted. All the participants signed an informed consent form before data collection.

Subjects

A convenience sample of 34 healthy individuals without pain in the low back or lower extremity (19 women and 15 men; mean [standard deviation] age, 25 ± 2.3 years) participated in this study. Subjects were recruited from the physical therapy student body at Washington University in St Louis, Missouri.

Procedures

The authors of this study were 2 experienced clinicians who performed all of the testing. Training sessions were held to establish consistency in testing methods between testers. Data from testing the first 18 subjects were used to determine intra-rater reliability. Strength measurements were taken for both the hip IRs and ERs in 2 positions for the subjects: (1) sitting with the hip and knee flexed to 90° (Figure 1A), and (2) supine with the hip in 0° of flexion and the knee in 90° of flexion (Figure 1B). In both positions, the hip was placed in neutral rotation, abduction, and adduction. For testing in the supine position, the untested extremity was positioned in hip and knee flexion with the foot on the table. This position for the untested extremity was selected for comfort and to decrease the stress on the lumbopelvic region.

A hand-held dynamometer (Hoggan Health Industries, West Jordan, UT) was used to measure the strength of the hip IRs and ERs in both positions. The device was placed against the distal lower leg just above the lateral malleolus for testing the IRs (Figure 1A) and just above the medial