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Influence of Body Position on Concentric Peak Torque of Hip Abductor and Adductor Muscles

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Abstract

Objective: The purpose of this study was to determine if peak torques generated by the hip abductor and adductor muscles are dependent on test position in healthy adults.

Methods: Thirty healthy right-handed volunteers participated in this study their average age was 26.5 ± 5.6 years, their average weight was 71.94 ± 11.91 kg, and their average height was 172.42 ± 6.60 m. Isokinetic peak concentric hip abductor and adductor muscles torques (Nm) generated in side-lying and standing positions at angular velocities 30 and 90°/s were measured.

Results: The concentric peak torque of abductor and adductor muscles measured from standing position were generally higher than side-lying position ($p<0.05$). The torque values of the hip abductor and adductor muscles at angular velocity 30°/s were higher than torque values at angular velocity 90°/s ($p<0.05$). At angular velocity 30°/s, there was no significant difference between hip abductor and adductor muscles in both positions ($p>0.05$). However, at angular velocity 90°/s, the torque values of hip abductors was significantly higher than torque values of hip adductors in both positions ($p<0.05$).

Conclusion: Isokinetic hip abductors and adductors strength measured in standing are higher than that measured from side-lying. These findings may have implications for rehabilitation and injuries prevention of hip abductors and adductors.

Keywords: Hip abductors and adductors; Body position; Concentric contraction

Introduction

Hip strength assessment plays an important role in clinical examination of the hip and groin region [1]. Clinical outcome measures quantifying hip muscle strength are needed [2]. Hip muscles strength can be assessed by different measurement tools as unreliable manual muscle testing [3], isokinetic devices [4-7] and portable dynamometers (handheld or stabilized) [8,9].

In clinics and laboratories isokinetic dynamometry is commonly used to assess muscle function and the reliability of peak torque measurements has been well established in healthy subjects [10]. However, factors such as angular velocity, stabilization and subject positioning are important because they can influence the ability to generate torque [10,11]. It follows that the conditions under which strength is measured may influence its ability to explain variance in task performance.

When evaluating lower-limb muscle strength, the conventional test positions are seated, supine, prone or side-lying depending on the muscle group of interest. Several researchers [12-14] have suggested that more accurate predictions of performance limitations based on strength measures might be achieved if the test position emulates how the muscles are used during functional activities. In this way the biomechanics relationship between segments is preserved and any neural or mechanical effects associated with body position are replicated [13].

Body position during assessment of muscle strength is one of the variables that must be controlled to ensure the validity and reliability of isokinetic dynamometer [15,16]. Assessment of hip abductor and adductors muscles strength is usually tested with the subject in side-lying position [10,17-19]. Widler et al. [20] assessed the isometric hip abductor muscle strength from supine, side-lying and standing positions. They found that the side-lying body position offers the most valid and reliable assessment of unilateral hip abductor strength. However, Cahalan et al. [7] suggested that standing position is the most functional position for the assessment of hip abductor muscles strength, Claiborne et al. [21] established a high test-retest reliability measurement of isokinetic hip abductors and adductors torque from standing position. Therefore, the purpose of this investigation was to examine the effect of the standing and side-lying position on concentric peak torque of hip abductor and adductor muscles.

Materials and Methods

Participants

Thirty healthy right-handed volunteers (14 male, 11 female) were chosen for this study from a population of college students. The subjects' average age was 26.5 ± 5.6 years, average weight was 71.94 ± 11.91 kg, and average height was 172.42 ± 6.60 m. Subjects with a history of orthopedic injury to lower extremity within the past year, cardiovascular, pulmonary, neurological, or systemic conditions that limit activity level were excluded from the study. Subjects who had undergone surgery, had a diagnosed low back injury, or had been diagnosed with a previous ligament injury of the knee, ankle or hip

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were also excluded from this investigation [21]. Subjects had to possess at least 45 degrees of passive hip abduction, as measured by standard goniometry [22].

Written consent was obtained from each subject before testing. After being informed about the study and test procedures, and any possible risks and discomfort that might ensue from the procedure, all subjects were screened to ensure that no lower extremity neuromuscular, musculoskeletal problems or contraindications for the isokinetic testing, The study was approved by the research ethical committee of the Faculty of Physical Therapy, Cairo University.

Instruments

During the testing sessions, subjects' hip abduction, adduction strength for the dominant leg were evaluated using the Biodex Isokinetic Dynamometer (System 3, Biodex Medical Systems, Inc, Shirley, NY), at a pre-set angular velocity of 30 and 90˚/s. Following a five-minute sub-maximal warm-up on a stationary cycle and 2-3 sub-maximal and maximal familiarization repetitions each subject performed three maximal-effort reciprocal contractions, abduction/adduction movement pattern for abductors and adductors. The single highest peak torque (Nm) value obtained during each set of three repetitions was used for statistical analysis. Previously reported to enhance performance concurrent visual feedback from a computer monitor and verbal encouragement were provided to all subjects to promote maximal efforts during all trials [23-27]. Two minutes of seated rest were provided between each set of three contractions. The cushion setting for all trials was in the "hard" position to minimize deceleration at the end of the range of motion that would have adversely affected torque generation during the subsequent contraction [28,29].

The motion in one direction was immediately preceded by motion into the opposite direction. This order of testing was chosen for purposes of experimental convenience and was assumed to have negligible effects on test–retest reliability [21]. The hip motions of abduction and adduction were evaluated with the subjects in a standing position and side-lying position. The abduction/adduction range of motion was set from 10 degree of hip adduction to 30 degree of hip abduction. The patient's weight and height were measured and recorded. To correct the influence of gravity effect torque on the data, the limb was weighed following the instructions from the dynamometer's operations manual. Test results were automatically corrected in the software for gravity effect torque.

Procedures

Side-lying position: The positions of the seat and the dynamometer were adjusted for measuring hip joint for abductors: dynamometer orientation 0º, dynamometer tilt 0º, seat orientation 0º, and seatback tilt fully reclined. The attachment of the hip (of tested side) was attached to the dynamometer. The patient lied in side-lying position on the chair of the apparatus with face away from dynamometer, the tested leg on top of the non-tested leg and the thigh of the non-tested leg and trunk were stabilized with straps. The dynamometer's rotation axis was aligned medial to the anterior superior iliac spine at the level of the greater trochanter on the tested leg and the seat height and position were adjusted for accurate alignment. The hip attachment length was adjusted to be proximal to the patient's lateral femoral condyle. The neutral position was used as starting position (Figure 1).

Standing position: The dynamometer orientation 0º, dynamometer tilt 0º, seat orientation 0º, the hip attachment was inserted into the knee adaptor and secured to the dynamometer. The attachment of the hip (of tested side) was attached to the dynamometer. The patient is stood facing the dynamometer, and using his hand on the dynamometer for support. The tested leg was attached to the dynamometer resistance adapter with a Velcro strap slightly above the knee. The dynamometer's rotation axis was aligned medial to the anterior superior iliac spine at the level of the anterior superior iliac spin on the tested leg. The hip attachment length was adjusted to be proximal to the patient's lateral femoral condyle. The neutral position was used as starting position (Figure 2).

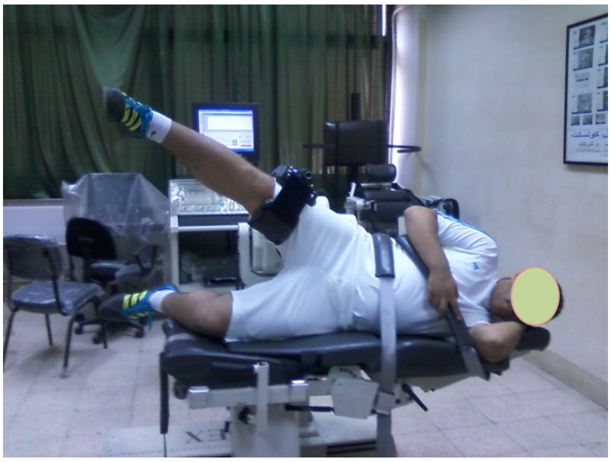

Figure 1: Hip abduction/adduction isokinetic test from side-lying position.

Figure 2: Hip abduction/adduction isokinetic test from standing position.

Statistical analysis: Data was analyzed using the Statistical Package for Social Sciences (SPSS version 16). Analysis of variance, with

Variables		Standing	Side-lying
Hip abductors	30°/sec	118.47 ± 33.77	80.60 ± 26.16
	90°/sec	83.77 ± 26.16	61.51 ± 28.67
Hip adductors	30°/sec	119.33 ± 32.92	82.57 ± 30.71
	90°/sec	61.88 ± 26.16	44.25 ± 24.14

Table 1: The mean values of concentric peak torque (± SD) for the hip abductor and adductor muscles at angular velocities 30 and 90°/s.

repeated measures, was used to investigate the effect of body position on peak torque production of the hip abductors and adductors at angular velocities of 30° and 90°/s respectively. The level of significant was set at 0.05 for all statistical tests.

Results

The concentric peak torque values of the hip abductors and adductors muscles at angular velocities 30 and 90°/s are shown in Table 1. The concentric peak torque values of the hip abductor and adductor muscles at angular velocity 30°/s were significantly higher than the torque values at angular velocity 90°/s ($p<0.05$).

Regarding the body position, the peak torque values of the hip abductor and adductor muscles measured from standing position were significantly higher than those measured from side-lying position at angular velocities 30 and 90°/s ($p<0.05$). For comparison between hip abductor and adductor muscles, at angular velocity 30°/s, there was no significant difference between hip abductor and adductor muscles in standing and side-lying positions ($p>0.05$). However, at angular velocity 90°/s, the peak torque values of hip abductors was significantly higher than peak torque values of hip adductors in standing and side-lying positions ($p<0.05$).

Discussion

This study was conducted to examine the effect of body position on the concentric peak torque of hip abductors and adductors muscles. The findings of this study indicated that the concentric peak torque of hip adductors and adductors muscles measured from standing position were higher than those recorded from side-lying position. Moreover, the torque values of the hip abductor and adductor muscles at angular velocity 30°/s were higher than the torque values at angular velocity 90°/s.

In relation to the two velocities studied, the peak torque diminished as the angular velocity increased from 30°/s to 90°/s, showing that the capacities to produce maximum torque is greater in low velocities of joint movement. The decrease in peak torque with the increase of angular velocity is supported by the findings of Kellis and Baltzopoulos [30]. They reported that from 60°/s, increase in the angular velocity produces a decline in torque of the concentric contractions. Such results were expected considering the assumed relationship between force versus velocity, which establishes that if the velocity of shortening is low, the tension that can be developed is high and, on the other hand, if the velocity of shortening is high, the tension that can be developed is low [31].

As for the comparison between the muscle groups, it was observed that there was no difference between hip abductor and adductor muscles torque values at angular velocity 30°/sin standing and side-lying position. However, at angular velocity 90°/s, the torque values of hip abductor muscles was significantly higher than torque values of hip adductor muscles in both body positions. This is inconsistent with the finding of Kea et al. [32] who reported that, at angular velocity 60°/s, the hip adduction torques were significantly greater than abduction torques during both concentric and eccentric muscle actions, from side-lying position. Moreover, Cahalan et al. [7] reported that without taking age or gender in consideration, the hip extensors were the strongest muscle group, followed by flexors, adductors, abductors, and rotators. As the velocity of exercise increase, the magnitude of the torques produced decrease.

In contrast to these studies, the results of a study conducted by Lourencin et al. [33] were somewhat consistent with the findings of the present study. They found that that the peak torque showed a greater values in the abductor muscles than in the adductor muscles at angular velocity 120°/s. They suggested that, at angular velocities higher than 90°/s, there may be more efficiency in the hip abductor muscles group.

Assessment of hip abductor and adductor muscles from side-lying and standing considered as non-weight-bearing test. Nordin and Frankel [34] stated that the non-weight-bearing standing hip and flexed-hip abduction exercises required less EMG activity than the non-weight-bearing side-lying hip abduction. To perform non-weight-bearing hip abduction, the hip abductors have to overcome an external torque equal to the mass of the right lower extremity times the external moment arm of that mass. Because the mass of the right lower extremity remained constant across the three exercises, the differences in external torque are attributed to changes in the external moment arm length, with the external moment arm being longer in the side-lying position [35]. However, the moment arm during conduction of the current study, the same in standing and side-lying, is the perpendicular distance from the hip joint to the cuff of Biodex dynamometer arm that lies just above the knee joint.

Widler et al. [20] found that the maximal hip abductor isometric strength was significantly higher in the side-lying position compared with the standing and supine positions and concluded that the side-lying body position offers the most valid and reliable assessment of unilateral hip abductor strength. These results are inconsistent with the results of present study. They measured the isometric contraction of hip abductors while the present study measured concentric contraction of hip abductors and adductors.

The higher torque of hip abductors and adductors recorded from standing position is consistent with the finding of Barbic and Brouwer [36] who found that the peak of hip flexor torques were about 28% higher when tested in a standing position compared with supine in healthy subjects. Moreover, Claiborne et al. [21] assessed the test–retest reliability of hip muscles from standing position. They found that the motions of concentric hip abduction (right and left), flexion (right and left), extension (right), internal rotation (right and left), eccentric hip abduction (left), adduction (left), flexion (right), and extension (right and left) demonstrated high torque reliability. However, Mognoni et al. [37] and Masuda et al. [38] tested the peak hip flexor torques for skilled soccer players in standing [37] and supine [38], they suggested that test position may not be an important factor, at least at the hip joint.

Bolgla and Uhl [35] concluded that the weight-bearing exercises and non-weight-bearing side-lying hip abduction exercise resulted in greater muscle activation because of the greater external torque applied to the hip abductor musculature. Although the non-weight-bearing standing hip abduction exercises required the least activation, they may benefit patients who cannot safely perform the weight-bearing or side-lying hip abduction exercises. These results combined with our findings, must be considered in developing a rehabilitation protocol. Therefore, weaker patients or patients who have recently sustained a hip injury or surgical intervention may be able to utilize these exercises early in the rehabilitation process. As patients become proficient with the non-weight-bearing standing hip abduction exercises, they may progress to non-weight-bearing side-lying hip abduction if they are unable to apply full weight bearing to the involved lower extremity.

There are some limitations of the current study. First, the gender in this study was limited to males only. Thus, the appropriateness of generalizing the results is confined to this specific population. Secondly, the angular velocities of this study, 30°/s and 90°/s, may be considered as slow and moderate angular velocities, and the results may be different if conducted at higher angular velocity. Finally, the only parameter examined in this study was concentric peak torque. Other isokinetic parameters, such as eccentric peak torque, total work and average power were not considered.

Conclusion

Evaluation of hip abductors and adductors musculature has been traditionally performed from the supine and side-lying positions. The results of current study proved that the standing position is more advantageous position as it most closely simulates a functional walking and running position as well as facilitating optimal torque generation. However, further research is needed to determine the effect of hip abductor and adductor muscles eccentric evaluation, rehabilitation, and injury prevention from standing position.

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