The Influence of Hip Position on Quadriceps and Hamstring Peak Torque and Reciprocal Muscle Group Ratio Values

Teddy W. Worrell, MEd, PT ATC[*], David H. Perrin, PhD, ATC[†], and Craig R. Denegar, PhD, ATC[‡]

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Abstract:
The purpose of this investigation was to determine the effect of hip position and test velocity on the quadriceps and hamstring reciprocal muscle group ratio. Twelve subjects (7 male, 5 female) were tested for isokinetic peak torque at 60, 180, and 240°/sec from the seated and supine positions. Gravity correction was obtained to determine quadriceps and hamstring peak torque, and to determine the reciprocal muscle group ratios. Results indicated there was a decrease in production of peak torque with an increase in test velocity for both muscle groups. Also, peak torque values were greater in the seated than supine position for both muscle groups. The influence of test velocity on the quadriceps and hamstring reciprocal muscle group ratio was to increase the ratio with increasing test velocity. Also, the reciprocal muscle group ratio increased from the supine to the seated position at all test velocities. These findings suggest that determination of the quadriceps and hamstring reciprocal muscle group ratio is influenced by both hip position and test velocity. Because many athletic activities involving running and sprinting occur from a hip position closer to the supine test position, evaluation of peak torque and determination of the reciprocal muscle group ratio may be more appropriate from the supine position. Also, normative data establishing target ratios should be determined from several test velocities.

Article:
Hamstring muscle strains represent a significant source of lower extremity injuries during athletic participation (1, 4, 5-10, 13, 14, 19-21, 23, 26, 33, 34). A plethora of research has reported normative hamstring strength while in a seated position (2, 6, 11, 18, 23-25, 27, 29, 31, 32, 35). However, athletic participation necessitates contraction of the quadriceps and hamstring muscle group from a hip position more closely approximating an extended position as found in supine. There is presently limited research (16) which examines the influence of

[*] Doctoral student sports medicine, University of Virginia, Charlottesville, VA 22901.
[†] Assistant professor and graduate curriculum director in athletic training, University of Virginia, Charlottesville.
[‡] Assistant Professor, Slippery Rock University, Slippery Rock PA.

supine versus sitting positions on peak torque production of the quadriceps and hamstrings, and on the hamstrings/quadriceps reciprocal muscle group ratio.

The hamstring-quadriceps reciprocal ratio describes the agonist-antagonist relationship of these muscle groups, and is determined by dividing the hamstring peak torque by the quadriceps peak torque. Several authors have suggested this relationship may be a factor in hamstring muscle injury and have recommended a minimal ratio of 0.60 at 60°/sec test speed (5, 9, 23).

Several factors confound the assessment of quadriceps and hamstring strength and determination of the hamstring/quadriceps reciprocal muscle group ratio. First, while most research has examined hamstring strength from a seated position (110° hip flexion) (2, 5, 11, 15, 24, 25, 2932, 35), close examination of this muscle groups' role during athletic participation indicates its strength would be more appropriately assessed from the supine position (10° hip flexion) (3, 15, 24-26). Second, research has established that as the velocity of isokinetic testing increases, generation of peak torque during knee extension and flexion decreases (2, 24, 29, 35). However, the effect of increasing test velocity on the hamstring/ quadriceps reciprocal muscle group relationship is to increase this ratio (2, 17, 24, 25, 29, 30, 35). Finally, failure to provide gravity-corrected values while assessing quadriceps and hamstring peak torque will result in different reciprocal muscle group ratios than when gravity correction is obtained (2, 3, 31, 35).

Some research has compared hamstring and quadriceps peak torque values obtained from the prone, seated, and supine positions (3, 15, 25). Limited research (16) examining the effect of test position on the hamstring/quadriceps reciprocal muscle group ratio with gravity-corrected values at several isokinetic test velocities has been reported. The purpose of this study was to determine the effect of two hip positions on quadriceps and hamstring muscle group peak torque at three isokinetic test velocities. Further, the hamstring/ quadriceps reciprocal muscle group ratios were determined at each test velocity using the gravity corrected values.

METHODS

Twelve university students, having no history of injury to either the hamstring or quadriceps muscle groups, volunteered as subjects (7 male, mean age = 23.4, mean weight = 75.7 kg; 5 female, mean age = 23.8, mean weight = 60.0 kg). Subjects were oriented to the isokinetic concept of exercise prior to testing, informed of the research purposes and possible risks, and then gave their consent to participate. A Cybex isokinetic dynamometer (Cybex, Ronkonkoma, NY) interfaced with a Cybex Data Reduction Computer was used for determination of quadriceps and hamstring muscle group peak torque.

Test positions determined with standard goniometry were 110° of hip flexion (seated) and 10° of hip flexion (supine). Subjects were stabilized at the thigh, pelvis, and trunk with straps in each test position. The axis of the dynamometer was aligned with the anatomical axis of the knee joint with the shin pad placed 2.5 cm proximal to the medial malleolus. The lever arm position was not changed from seated to supine test positions. The order of test position and side was randomized. Subjects were required to fold their arms across their chests to minimize extraneous body motion and the effect of accessory muscle group contraction. Gravity correction was determined for each subject following the manufacturers' recommended protocol.

Following a stretching warm-up period, the test protocol consisted of three submaximal and three maximal practice repetitions, followed by six maximal test repetitions at each test velocity. Bilateral peak torque values were obtained at velocities of 60, 180, and 240°/sec at each test position. One minute rest was permitted between each test velocity.

The hamstring peak torque, quadriceps peak torque, and hamstring/quadriceps reciprocal muscle group ratios were analyzed with an analysis of variance (ANOVA). A one between (gender), three within subject factors leg (dominant versus nondominant), position (seated and supine), speed (60, 180, and 240°/sec) ANOVA was performed for each dependent measure.

RESULTS

Peak torque values obtained from the seated and supine positions for the quadriceps and hamstring muscle groups for all subjects are presented in Figures 1 and 2. There was a significant decrease in hamstring [$F(1,10) = 183.3$, $p < 0.01$], and quadriceps [$F(1,10) = 298$, $p < 0.01$] peak torque values with increasing test velocity. For all subjects, both hamstring [$F(1,10) = 54.0$, $p < 0.01$] and quadriceps [$F(1,10) = 5.6$, $p < 0.05$] peak torque values were greater in the seated position than in the supine position at all test speeds. Males generated greater peak torque than females ($p < 0.01$) for both muscle groups (Figs. 1 and 2).

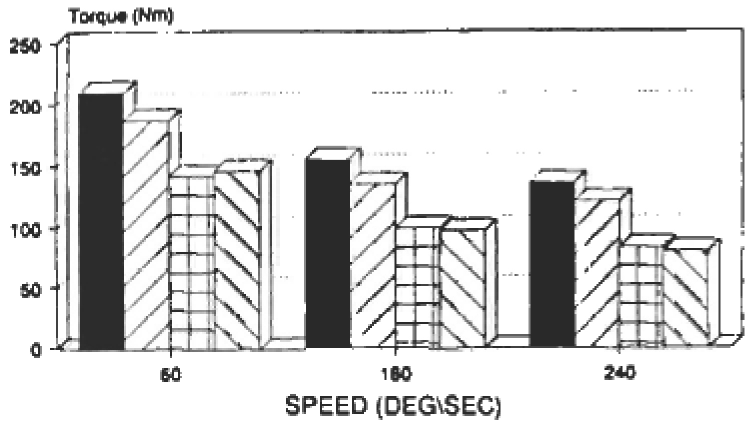

Figure 1. Quadriceps peak torque values. (■), male seated; (◫), female seated; (◩), male supine; (◪), female supine.

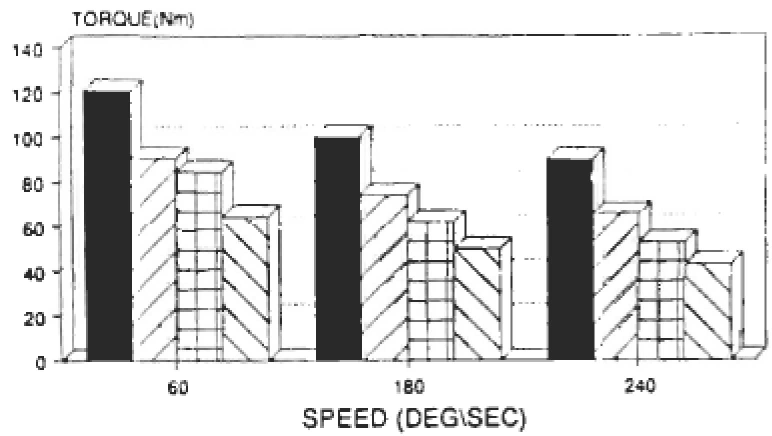

Figure 2. Hamstring peak torque values. See legend to Figure 1 for key to bars.

A comparison of bilateral peak torque values for both muscle groups revealed no significant differences. Average right and left peak torque values were within 3% for the quadriceps and 9% for the hamstrings at all test speeds and positions.

Figure 3 presents the reciprocal muscle group ratios obtained from both test positions. The hamstring/quadriceps reciprocal muscle group ratio increased with increasing test velocity in both the supine and seated position for all subjects [F(1,10) = 17.8, $p < 0.01$]. Also, the hamstring/quadriceps reciprocal muscle group ratio increased from the supine position to the seated position at all test velocities [F(1,10) 110,$p<0.01$].

DISCUSSION

The results of this study demonstrated that hamstring peak torque values were influenced by hip position. Hamstring peak torque values were significantly less in the supine than the seated position for all test speeds. These results are consistent with the findings of others (12, 16, 25).

Lunnen et al. (25) examined isometric hamstring torque values at 60° of knee flexion and hip positions of 0, 45, 90, and 135° of flexion. They found peak isometric hamstring torque values were significantly less at 0° than at 90 and 135° of hip flexion. Felder (15) tested isometric and isokinetic hamstring torque production from the seated, prone, and supine positions. He also found that the greatest hamstring torque production was in the seated position.

The mechanism for these observed reductions in hamstring force production are presumably related to the length-tension curve which describes an optimal length at which a muscle can develop maximal force (22). In the shortened hamstring position of 10° of hip flexion, actinmyosin cross-bridging does not occur as efficiently. However, in the seated position (110° hip flexion) the hamstrings are lengthened and a more optimal actin-myosin cross-bridging occurs. The result is a greater force production capacity.

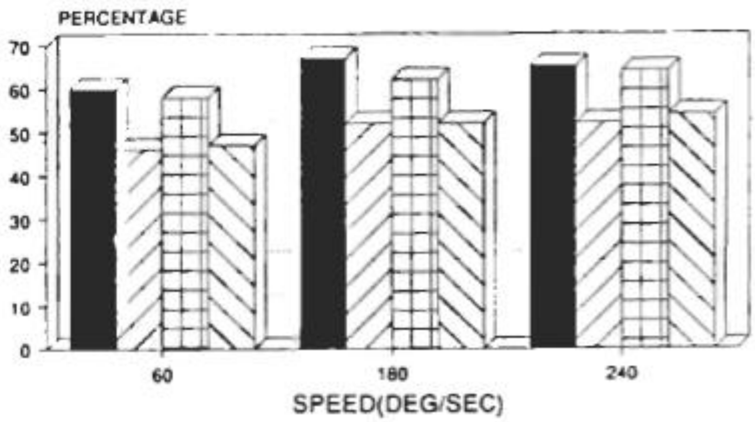

Figure 3. Ham/quad peak torque ratios. See legend to Figure 1 for key to bars.

Hip position also influenced quadricep peak torque production. There was a significant decrease in peak torque values during knee extension in the supine position compared to the seated position. This finding is consistent with Currier (12) who found the greatest isometric quadriceps force production at 60° knee flexion from a hip position between 110 and 130°.

Although peak torque was assessed in an isokinetic mode in this investigation, the length-tension relationship of the rectus femoris and hamstrings should respond in a similar fashion in isometric evaluation. That is, when the hip is positioned between 110 to 130° of flexion, optimal actin-myosin cross-bridging occurs for both muscle groups which allows for maximal torque production. Hip angles greater than 130° or less than 90° do not provide the optimal length-tension relationship and thus less torque can be produced.

Our findings indicated that the greatest hamstring and quadricep torque was produced from the seated position. In supine, the hamstrings are placed in an inefficient shortened position, and the rectus femoris is placed in an inefficient lengthened position. The concept of length-tension is further demonstrated when examining the hamstring/quadriceps reciprocal muscle group ratio. There was a significant decrease in this ratio from the seated to the supine position (Fig. 3). The decrease in the hamstring muscle group peak torque values were approximately twice that of the quadriceps peak torque values. This may be explained by the fact that three of the quadricep muscles do not cross the hip joint, while three muscles of the hamstring group cross both the hip and knee joints. Therefore, the quadriceps muscle group was not influenced to the extent that the hamstring muscle group was by a change in hip position. These findings are consistent with Figoni et al. (16) who found that changing the hip angle had a greater influence on hamstring peak torque values than quadriceps values. However, our findings are in conflict with Felder (15) who found no differences in quadricep force production isotonically or isokinetically in the seated or supine positions.

Our findings pose an important clinical question: should exercise and evaluation occur from a position facilitating maximal torque production or from a position replicating a functional position? Mann's (26-28) analysis of running and sprinting demonstrated the position of the hip to be closer to 0-10° of flexion. With this in mind, evaluation of athletes involved in running and sprinting activities would seem most appropriate from the supine position. Also, because hamstring/quadriceps muscle group ratios decreased from sitting to supine positions, normative data establishing target ratios should be determined from the supine position.

This investigation examined the influence of hip position on hamstring and quadriceps peak torque and the recriprocal muscle group ratio in a population of general university students. The differences observed between the two test positions in this population suggest a need to explore the influence of hip position in an athletic population of runners and sprinters. Presumably, the variation between muscle groups from the two test positions would be similar in athletes, and thus suggestive of the need to consider assessment from the supine position.

CONCLUSION

Traditional evaluation and rehabilitation of hamstring and quadriceps musculature has been performed while in the seated position. Our findings suggest that evaluation and rehabilitation should be performed in the supine position since this position more closely simulates muscle function and length-tension relationships which occur during running.

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