Effect of Body Position on Hamstring Muscle Group Average Torque

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Abstract:
The purpose of this investigation was to examine the effect of the supine and prone position on concentric and eccentric isokinetic strength of the hamstring muscle group. Twelve university female lacrosse players were tested for hamstring average torque on a Kinetic Communicator® dynamometer at 60°/sec from the supine and prone positions. Analysis of variance indicated average torque generated from the prone was greater than the supine position. Greater torque was also generated during eccentric contraction than during concentric contraction. The influence of the tonic labyrinthine and the symmetrical tonic neck reflexes is proposed as the mechanism for the differences observed between the two test positions. The prone position facilitates optimal generation of torque while approximating a length-tension relationship observed during sprinting. These findings suggest consideration be given to assessment and strength training of the hamstring muscle group in the prone position.

Article:
Isokinetic dynamometry has become an integral component of the sports medicine clinician's repertoire in evaluation and rehabilitation of athletic injuries in the 1980s. Isokinetic dynamometers are routinely used to assess lower extremity musculature. Specifically, the quadriceps and hamstring strength measures and hamstring/ quadriceps reciprocal muscle group ratios are assessed during evaluation and rehabilitation. Clinical decisions are frequently based on these indices. However, a number of factors may con-found these results including velocity (8, 19), test angle (8), and test position (1, 4, 8, 19). Several authors have reported the effect of body position upon quadriceps and hamstring isometric (4, 11, 12) and concentric peak torque values (1, 8, 19). However, it has been suggested that the mechanism responsible for the differences seen in peak torque production is unclear (1).

The influence of position (prone versus supine) upon eccentric hamstring peak torque measures, to our knowledge, has not been reported in the literature. Therefore, the purpose of this study was to re-examine the effect of position upon concentric hamstring strength measures and to determine the effect of body position upon eccentric hamstring strength measures.

METHODS
Twelve university female lacrosse athletes (age = 18.83 years, weight = 62.32 kg, height = 166.92 cm) were randomly selected to participate in this study. Prior to participating in this study, each subject signed a consent form which explained the purpose, procedures, risks, and benefits of the study. The Kinetic Communicate® (Kin-Com) was calibrated following the manufacturer's recommendations (Chattex Corp., 101 Memorial Drive, P.O. Box 42887, Chattanooga, TN 37405) (3).

Stabilization of the pelvis and thigh was provided by straps during testing in the supine position (Fig. 1). During testing in the prone position, stabilization of the pelvis was provided by a strap while the surface of the table provided stabilization of the thigh (Fig. 2). The axis of the dynamometer was aligned with the anatomical axis of the knee joint with the shin pad placed 1-1.5 inches proximal to the medial malleolus. The length of the lever arm was recorded for each testing position. The counterforce was set at 50 N. Each subject performed three warm-up repetitions followed by one maximum warm-up effort. A 1-minute rest period preceded three maximal contractions which were then recorded. There was a 5-sec interval between concentric and eccentric contractions. Standardized verbal encouragement was given to each subject during the testing procedure.

Figure 1. Supine position for assessment of hamstring muscle group average torque.

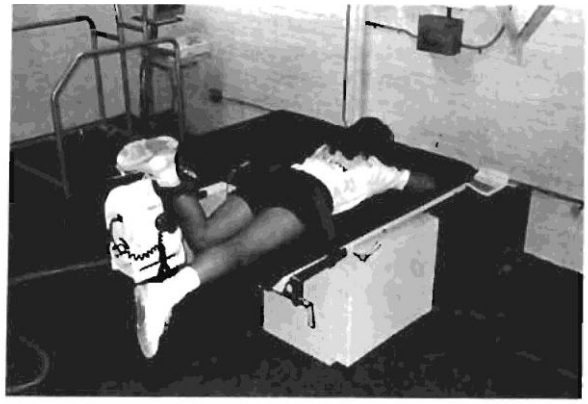

Figure 2. Prone position for assessment of hamstring muscle group average torque.

Hamstring muscle group strength was assessed in both the supine and prone positions. The starting position of the hip joint was identical in both test positions; however, during prone testing, despite maximal stabilization, there was an increase in hip flexion of approximately 10-20°. In prone position, the head was maintained in 30-45° extension. In supine, the head was maintained in 0° of flexion. Gravity correction was determined for each testing position and subject following the manufacturer's recommended protocol (3). The order of testing position and mode of contraction was randomized. All testing was performed in one session.

The Kin-Com dynamometer was utilized in both eccentric and concentric modes at 60°/sec. Average torque (newton-meters) was recorded through -80° to -10° of knee range of motion.

To examine for differences between position, side and mode of contraction, the average hamstring torque data was analyzed using a three-within subject factors analysis of variance (AN-OVA). A $p < 0.05$ level of significance was accepted.

RESULTS

The mean and standard deviation values for hamstring muscle group average torque are presented in Table 1. Average torque generated from the prone position was significantly greater [$F(1,11) = 165.0$, $p < 0.01$] than from the supine position. Significantly greater [$F(1,11) = 117.8$, $p < 0.01$] torque was generated during eccentric contraction than during concentric contraction. The lack of a significant position (supine versus prone) by mode (concentric versus eccentric) interaction [$F(1,11) = 0.47$, $p > 0.05$) indicated that body position had a similar effect on concentric and eccentric hamstring torque production. Analysis of variance did not reveal significant differences by side [$F(1,11) = 0.11$, $p > 0.05$). Therefore, these data were collapsed for graphic presentation (Fig. 3).

DISCUSSION

The relevant clinical issue is that the prone position allows maximal force development of the hamstring musculature while maintaining length-tension relationships similar to function (1, 11). The lowest mean average torque generated concentrically from the prone position was 17% greater than the highest mean average torque generated eccentrically from the supine position. These findings suggest that consideration of the prone position be utilized for hamstring evaluation and training. Caution should be exercised in this position due to the larger forces generated by the hamstring muscle group.

TABLE 1

*Hamstring muscle group average torque (mean± SD)**

	Concentric		Eccentric	
	Right	Left	Right	Left
Prone	63.9 (8.8)	63.3 (12.3)	79.4 (17.5)	81.4 (18.3)
Supine	40.4 (9.5)	40.3 (9.0)	55.4 (14.5)	55.5 (11.1)

* Average torque in newton-meters.

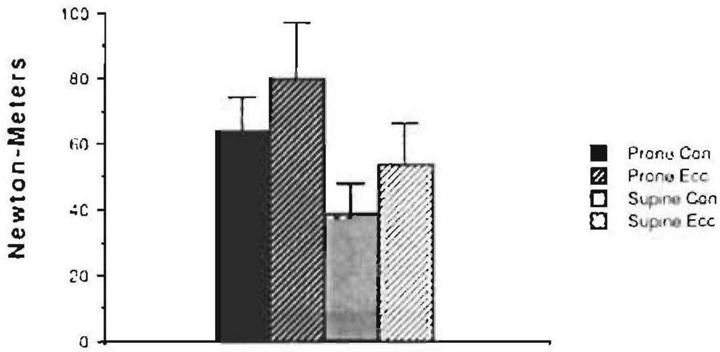

Figure 3. Hamstring muscle group average torque by position and mode of contraction.

The recent innovation of isokinetics permits evaluation through both a concentric and eccentric mode of contraction. There are several major advantages to assessing and exercising the hamstring muscle group from the prone position. First, the prone position approximates the functional length-tension relationship occurring during sprinting. At ground contact the hip and knee are in 30-45° of flexion (13, 16). The traditional seated testing position of 90-110° hip flexion is not in the functional range of motion. Second, during sprinting the hamstrings are contracting both concentrically and eccentrically at both the hip joint and at the knee joint (9, 18). It appears that this situation can be closely simulated in the prone testing position. Third, the prone position allows for much greater tension development within the musculotendinous unit than from the supine position, as revealed by the significantly greater torque values. However, isokinetic evaluation and training are open kinetic-chain activities, whereas sprinting is a closed-chain activity. Therefore, caution should be utilized in extrapolation of isokinetic results to function.

The results of this study demonstrated that both eccentric and concentric average hamstring torque values were influenced by test position. Hamstring average torque values were significantly greater in the prone than the supine position. These results are in agreement with others (1, 11). In a study to validate the Nelson-Duncan gravity correction equation (14), Barr and Duncan (1) observed significantly greater concentric hamstring peak torque values from prone compared to supine. The authors discussed two possible explanations for the increase in concentric hamstring peak torque in the prone position. These were: a psychological factor in which subjects reported the prone position was more difficult, possibly causing them to exert greater effort, and the influence of the tonic labyrinthine reflex to facilitate flexor tone.

Houtz et al. (11) reported the influence of position (seated, supine, and prone) upon maximal isometric hamstring and quadriceps values. Hamstring isometric torque was greater in prone than supine position. The authors proposed the influence of postural reflexes as an explanation.

We postulate the mechanism for the significant change in hamstring muscle torque indices may be related to postural reflexes since the length-tension relationship of the hamstring muscles is similar in both positions.

Sherrington (15) discussed the influence of tonic labyrinthine (TLR), symmetrical tonic (STNR), and asymmetrical tonic neck (ATNR) reflexes upon animal models. Bobath (2) discussed the influence of these postural reflexes on brain-injured infants and adults. Moreover, Hellebrandt et al. (10) demonstrated the influence of the ATNR upon normal subjects' ability to generate wrist flexion and extension work production. Both the TLR and TNR may influence hamstring and quadriceps torque indices. The tonic neck reflexes primarily influence the upper extremity (2). However, lower extremity influence has been documented (17). Rotation of the head results in an increased extensor muscle tone in the extremities on the "jaw side" and increased flexor muscle tone in the extremities on the "skull side" (2). In the prone position, the STNR is evoked by flexion and extension of the head. Flexion of the head facilitates an increase in upper extremity flexor muscle tone and lower extremity extensor muscle tone. Extension of the head facilitates upper extremity extensor muscle tone and lower extremity flexor tone (2).

The TLR also involves the position of the head. The vestibular system (semicircular canals, otolith, and maculae) are located in the inner ear and are responsible for the complex modulation of muscle tone. These structures form an intricate arrangement that facilitates or inhibits muscle tone relative to the position of the head in space (5). In the prone position there is an increase in flexor muscle tone and in the supine position there is an increase in the extensor muscle tone in all four extremities.

We have observed that there is a concomitant increase in bilateral hip flexion during both isotonic and isokinetic evaluation and training of the hamstrings from the prone position. Maximal stabilization of the pelvis and femur will not completely eliminate this phenomenon. This has been observed by other investigators as well (11). It has been proposed that the influence of the tonic labyrinthine reflex is to increase flexor tone in both the iliopsoas and hamstring musculature, resulting in the significant increase in hamstring torque indices at the knee (11). Apparently, the influence of the iliopsoas at the hip joint is to increase the hip flexion which has been observed clinically. Rotation of the head (ATNR) does not prevent this phenomenon from occurring. Observation of Barr and Duncan's (1) work revealed during their testing protocol that subjects in the prone position placed their heads in an ATNR position, which theoretically would have increased extensor tone in the tested extremity. However, the authors reported significantly greater torque in the prone position. It would appear the TLR exhibits greater influence than the ASTN. The influence of the STNR may have an effect on hamstring muscle tone since the subjects in our study assumed a head position of extension while in the prone testing position. This would have been facilitory to the hamstring musculature in conjunction with TLR.

The importance of position and the length-tension relationship has not been adequately addressed (16, 19). Stanton and Purdam (16) recently discussed the role of position and contraction mode on hamstring rehabilitation. These authors recommended an eccentric protocol utilizing a modified prone position (prone with the hip in 30° flexion). The patient rapidly extends the knee to approximately 20-30° from full extension, then "catches" the lower leg via an eccentric/concentric contraction of the hamstring muscles. They reported during high speed, digitized filming that angular velocities of knee motion were close to 1000°/sec and peak torque values between 225 and 300 Nm during the late eccentric and early concentric phase of the catch. Unfortunately, the authors did not report any data demonstrating the effects of this protocol upon strength indices or injury prevention. There is limited literature supporting the prone position for rehabilitation (6, 7). We are unaware of any literature that recommends the prone position for evaluation.

Our subjects were female collegiate athletes; however, we have previously demonstrated that positional changes similarly affect males' and females' hamstring torque indices (18). Others have reported similar findings for male and female subjects (1, 11).

CONCLUSION

Evaluation and rehabilitation of the hamstring musculature has been traditionally performed from the seated position. Recently, other positions have been recommended (16, 19). These data suggest that the prone position may be a more advantageous position as it most closely simulates a functional running/sprinting position as well as facilitating optimal torque generation. However, further study is needed to determine the relationship of position to hamstring muscle assessment, rehabilitation, and injury prevention.

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