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original research

Influence of Hip-Flexion Angle on Hamstrings Isokinetic Activity in Sprinters

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Context: Hamstrings strains are common and debilitating injuries in many sports. Most hamstrings exercises are performed at an inadequately low hip-flexion angle because this angle surpasses 70° at the end of the sprinting leg's swing phase, when most injuries occur.

Objective: To evaluate the influence of various hip-flexion angles on peak torques of knee flexors in isometric, concentric, and eccentric contractions and on the hamstrings-to-quadriceps ratio.

Design: Descriptive laboratory study.

Setting: Research laboratory.

Patients and Other Participants: Ten national-level sprinters (5 men, 5 women; age = 21.2 ± 3.6 years, height = 175 ± 6 cm, mass = 63.8 ± 9.9 kg).

Intervention(s): For each hip position (0°, 30°, 60°, and 90° of flexion), participants used the right leg to perform (1) 5 seconds of maximal isometric hamstrings contraction at 45° of knee flexion, (2) 5 maximal concentric knee flexion-extensions at 60° per second, (3) 5 maximal eccentric knee flexion-extensions at 60° per second, and (4) 5 maximal eccentric knee flexion-extensions at 150° per second.

Main Outcome Measure(s): Hamstrings and quadriceps peak torque, hamstrings-to-quadriceps ratio, lateral and medial hamstrings root mean square.

Results: We found no difference in quadriceps peak torque for any condition across all hip-flexion angles, whereas hamstrings peak torque was lower at 0° of hip flexion than at any other angle ($P < .001$) and greater at 90° of hip flexion than at 30° and 60° ($P < .05$), especially in eccentric conditions. As hip flexion increased, the hamstrings-to-quadriceps ratio increased. No difference in lateral or medial hamstrings root mean square was found for any condition across all hip-flexion angles ($P > .05$).

Conclusions: Hip-flexion angle influenced hamstrings peak torque in all muscular contraction types; as hip flexion increased, hamstrings peak torque increased. Researchers should investigate further whether an eccentric resistance training program at sprint-specific hip-flexion angles (70° to 80°) could help prevent hamstrings injuries in sprinters. Moreover, hamstrings-to-quadriceps ratio assessment should be standardized at 80° of hip flexion.

Key Words: injury prevention, eccentric exercises, length-tension relationship, hamstrings-to-quadriceps ratio, muscle strains

Key Points

- Hip-flexion angle influenced hamstrings peak torque in isometric, concentric, and eccentric contractions.
- As hip flexion increased, hamstrings peak torque and hamstrings-to-quadriceps ratio increased, suggesting hamstrings-to-quadriceps ratio norms should be defined for a given hip angle; we propose 80° of hip flexion.
- The efficiency of hamstrings strengthening exercises could be improved by controlling hip angle.

Most hamstrings muscle strain injuries occur while running or sprinting.[1] Researchers have reported that hamstrings strain accounts for 50% of all muscular injuries in sprinters,[1] with an incidence varying from 10% (1-year follow-up) to 24% (2-year follow-up).[2,3] In addition, the hamstrings are the second most common injury site in team sports, but the incidence of injury can vary from one field position to the next. In rugby, the incidence is greater for backs than forwards, probably due to their greater acceleration, deceleration, and high-speed running demands.[4] In football, the speed-position players (ie, wide receivers, defensive secondary) are at elevated risk for injury.[5] In Australian Rules football, hamstrings muscle strain is the most frequent injury that results in time missed from participation.[6] In soccer, muscle strains represent 30% of the injuries, and 28% of these strains involve the hamstrings.[7]

During sprinting, the risk of injury is at its highest in the late swing phase and is higher for the biceps femoris than for the medial hamstrings.[8,9] From a structural point of view, sprint-related hamstrings tears affect mainly the passive components of muscle fibers (ie, tendon, myotendinous junction, or epimysium).[10,11] According to Garrett et al,[12] the higher risk of injury for the biceps femoris could be due to its specific architecture (ie, unique dual innervations, lateral distal insertion, shorter fiber length compared with the semitendinosus, increased pennation angle with knee flexion). From a kinematic point of view, the second half of the swing phase brings the hip into flexion at an angle of more than 70°, with the knee extending to less than 40° of flexion at a velocity greater than 1000° per second.[7,8,13–15] This hip angle of 70° to 80° is specific to sprinting (Figure A[a–c]). Because the hamstrings are biarticular muscles, the combination of hip flexion and

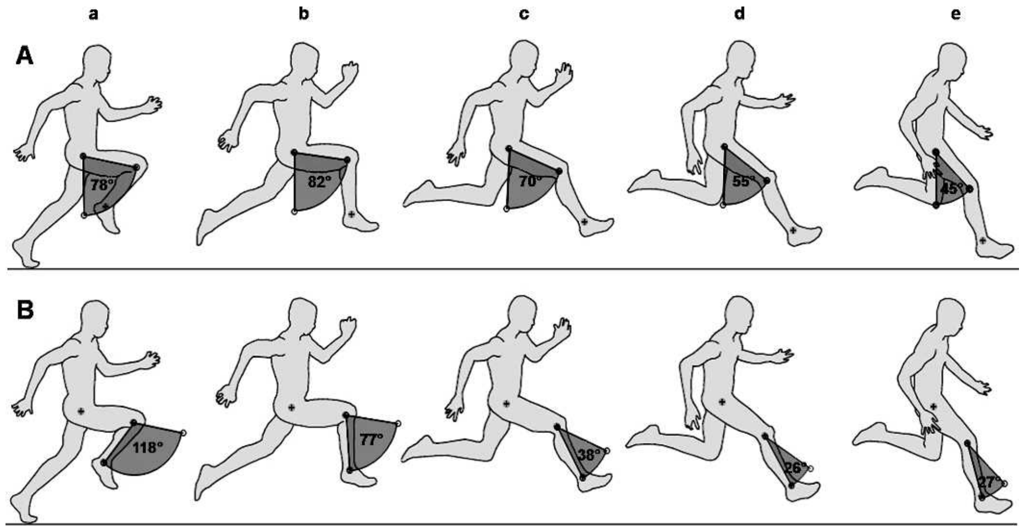

Figure. A, Hip flexions, and B, knee flexions, at about [a]75%, [b]80%, [c]85%, [d]90%, and [e]95% of the gait cycle of a world-class sprinter during a 100-m sprint. Letters a to c correspond with the specific hip-flexion position during sprinting. To determine elongation stress on hamstrings, subtract the angle in B (amount of knee flexion) from A (amount of hip flexion); a higher positive value indicates more elongation.

knee extension induces a substantial hamstrings muscle-tendon stretch. This stretch is even more pronounced due to the contralateral hip extending at the same time; this hip extension prevents the pelvis from tilting posteriorly, which would decrease the hamstrings stretch. A slight pelvis oscillation around its average angular position has been reported over the running cycle.[16] Therefore, the late swing phase causes the semimembranosus, semitendinosus, and long head of the biceps femoris to be stretched by 7.4%, 8.1%, and 9.5%, respectively, beyond their upright lengths.[8] The work of the hamstrings at this point is negative, and the electromyographic (EMG) activity shows peak activities in the medial biarticular hamstrings (MH) and lateral biarticular hamstrings (LH).[8,14,15,17] In summary, this active lengthening contraction in a stretch position at a high velocity during the late swing phase of the sprinting gait cycle corresponds to the time of highest injury risk for the hamstrings (ie, mainly the biceps femoris).

Current hamstrings injury-prevention programs are based on eccentric training. It has been shown to be an efficient method to increase strength and the hamstrings-to-quadriceps (H:Q) ratio, modify optimal hamstrings length (ie, angle of maximal peak torque), and eventually prevent injuries.[18–22] However, most of these investigators have used training methods or devices with either no hip flexion (eg, Nordic hamstrings exercise)[20] or nonspecified flexion (eg, yo-yo flywheel ergometer).[18] Moreover, probably the most-used hamstrings strength device is the prone hamstrings curl, which positions the hip at a nonspecific angle regarding sprinting biomechanics. In fact, during all these "classic" strength exercises, the hamstrings muscle-tendon complex is not stretched to the extent it is at the end of the swing phase (Figure).

As mentioned, the hip is in a flexed position during the late swing phase. Given the biarticular nature of the hamstrings, this hip-flexion position influences muscle activity. Several researchers[23–26] have shown that both isometric and concentric knee-flexion torques are greater when the hip is flexed (seated) rather than extended (supine). However, none of these authors has explored the influence of hip-flexion angle on hamstrings peak torque during eccentric contraction. Worrell et al[26] investigated the influence of hip flexion on H:Q ratio and found a greater ratio in the seated than prone position. Most H:Q ratio assessments are performed in a seated position (ie, between 70° and 90° of hip flexion). To reliably compare individuals, we need a consensus on a more precise hip-flexion angle for isokinetic evaluation. This consensus exists already for the angular velocity and the contraction mode.[27]

Therefore, the purpose of our study was to evaluate the influence of various hip-flexion angles on peak torques of knee flexors in isometric, concentric, and eccentric contractions and on H:Q ratio. A better understanding of the role of hip-flexion angle in hamstrings activity is required for improving hamstrings strength training and testing regarding the specifics of the sprinting gait cycle.

METHODS

Participants

Ten national-level sprinters (5 women, 5 men; age = 21.2 ± 3.6 years, height = 175 ± 6 cm, mass = 63.8 ± 9.9 kg) volunteered for this study. All were recruited at the local track-and-field club. To be included, participants had to be short-track (100 m, 110-m hurdles, 200 m) or long-track (400 m or 400-m hurdles) sprinters and to have had no injury in the 3 months before the study. Participants provided written informed consent, and the study was approved by the faculty of Biology and Medicine, University of Lausanne.

Experimental Design

Participants were tested in a temperature-controlled laboratory and were instructed not to exercise in the 48 hours before the study. After preparation for EMG recordings, they performed a 10-minute warm-up on a cycling ergometer. Next, they were seated correctly on an isokinetic dynamometer (Biodex System 2; Biodex Medical

Systems, Shirley, NY). The distal portion of the dynamometer arm was strapped proximal to the ankle joint, and the axis of rotation at the knee was aligned with the lateral femoral condyle of the knee. The thigh was stabilized. The back support of the Biodex was positioned to fix the hip angle of the participants in the adequate articular amplitude. Participants were secured on the seat with stabilization straps so they would be as stable as possible during the whole assessment.

For each hip-flexion angle (0°, 30°, 60°, 90°), participants performed (1) 5 seconds of maximal isometric hamstrings contraction of the right leg at 45° of knee flexion (ISO), (2) 5 maximal concentric knee flexion-extensions of the right leg at 60° per second (CON60), (3) 5 maximal eccentric knee flexion-extensions of the right leg at 60° per second (ECC60), and (4) 5 maximal eccentric knee flexion-extensions of the right leg at 150° per second (ECC150). They rested for 4 minutes between sets. Two sets of measures were performed at the same time of day; the first session assessed hip-flexion angles of 0° and 60°, and the second 14 days later assessed hip-flexion angles of 30° and 90°. Assessment order was not randomized.

Quadriceps and hamstrings peak torques were measured by the isokinetic dynamometer in ISO (hamstrings only), CON60, ECC60, and ECC150 at the various hip-flexion angles. Electromyographic data for the LH and MH were recorded (Myomonitor III; Delsys Inc, Boston, MA) by using surface EMG electrodes that had a DE-2.1 single-differential parallel-bar configuration with an interelectrode distance of 10 mm, bandwidth of 20 to 450 Hz, and a common mode rejection ratio of 80 dB per decade. The EMG electrodes were attached lengthwise over the muscle belly according to the recommendations for sensor locations on individual muscles developed by the Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles project.[28] The position of the electrodes was marked on the skin so that they could be fixed in the same place at the second set of measurements. The reference electrode was placed on the right patella. Low impedance (<5 kΩ) of the skin electrode was obtained by abrading the skin with emery paper and cleaning it with alcohol.[29] The root mean square (RMS) was calculated over a 500-millisecond interval around the peak torque value (ie, 250 milliseconds before and 250 milliseconds after the peak torque) for each muscle.

Statistical Analysis

The data were distributed normally. Peak torques and RMS were compared with a 2-way (hip-flexion angle [0°, 30°, 60°, 90°] by condition [ISO, CON60, ECC60, ECC150]) analysis of variance (ANOVA) with repeated measures. We used a Tukey post hoc test to localize the differences between means. The α level was set at .05. We used SigmaPlot (version 11.0; Systat Software, Inc, San Jose, CA) to analyze the data.

RESULTS

Results are presented in the Table as mean ± standard deviation.

Peak Torque

We found differences among hip angles ($F_{3,9} = 68.163$, $P < .001$). In each condition, hamstrings peak torque was lower at 0° of hip flexion than at any other angle ($P < .001$). Hamstrings peak torque was greater at 90° of hip flexion than at 30° and 60° ($P < .05$) except in CON60, where peak torques at 60° and 90° were not different ($P = .20$). We found differences among conditions ($F_{3,9} = 25.596$, $P < .001$). At each hip-flexion angle, hamstrings peak torque was greater in ECC60 and ECC150 than in ISO and CON60 ($P < .05$) except at 0°, where peak torque in ECC60 and CON60 were not different ($P = .052$). At each hip-flexion angle, we found no difference between ECC60 and ECC150 ($P > .05$).

In each condition, we found no difference in quadriceps peak torque across all hip-flexion angles ($F_{3,9} = 0.724$, $P = .55$). We found differences among conditions ($F_{2,9} = 11.556$, $P < .001$). At each hip-flexion angle, quadriceps peak torque was greater in ECC60 and ECC150 than in CON60 ($P < .05$) except at 90°, where peak torques in ECC150 and CON60 ($P = .06$) were not different. At each hip-flexion angle, we found no difference between ECC60 and ECC150 ($P > .05$).

Hamstrings-to-Quadriceps Ratio

We found differences among hip angles ($F_{3,9} = 19.867$, $P < .001$). At 0° of hip flexion, the concentric hamstrings-to-concentric quadriceps ratio at 60° per second (H_{con60}:Q_{con60} ratio) was lower than at the other angles ($P < .01$). Similarly, at 0° of hip flexion, the eccentric hamstrings-to-concentric quadriceps ratio at 60° per second (H_{ecc60}:Q_{con60} ratio) was lower than at the other angles ($P < .01$). The H_{ecc60}:Q_{con60} ratio was greater at 90° than at 30° of hip flexion ($P < .01$). We found differences among conditions ($F_{1,9} = 14.913$, $P = .004$). At each hip-flexion angle, the H_{ecc60}:Q_{con60} ratio was greater than the H_{con60}:Q_{con60} ratio ($P < .05$).

Root Mean Square of Muscle Activation

We found no difference in RMS of the LH across the range of hip-flexion angles ($F_{3,9} = 5.455$, $P = .006$) except in ISO, where 30° of hip flexion produced greater RMS of hip flexion than 90° produced ($P = .01$). We found differences among conditions ($F_{3,9} = 7.484$, $P = .001$). At each hip-flexion angle, RMS of the LH was lower in ECC150 than in CON60 ($P = 01$). In addition, RMS of the LH at 0° was also lower in ECC60 than in CON60 ($P < .01$). At 0° and 90°, RMS of the LH was greater in CON60 than in ISO ($P = .02$ and $P = .046$, respectively). At each hip-flexion angle, no differences in RMS of the MH were found among any conditions ($F_{3,9} = 1.110$, $P = .37$).

DISCUSSION

We examined the force produced by hamstrings and quadriceps muscles in various contraction modes and hip-flexion angles. Our main finding was that as the hip was flexed more, the hamstrings peak torque increased, regardless of the contraction regimes or isokinetic velocities for which we tested. For the isometric or concentric contractions at 60° per second, our results were in agreement with findings reported in the literature.[23–26] However, no researchers have examined torque and muscle activation in eccentric contractions while introducing another factor, specifically hip-flexion angle. We believe that assessing

Table. Hamstrings and Quadriceps Peak Torques, Hamstrings-to-Quadriceps Ratio, Lateral and Medial Hamstrings Electromyographic Activity at Various Hip-Flexion Angles and Conditions (Mean ± SD)

	Hip-Flexion Angle			
Variable	0°	30°	60°	90°
Hamstrings peak torque, Nm				
ISO	62.0 ± 15.8	88.8 ± 18.2[a,b]	96.4 ± 26.8[a,b]	110.1 ± 26.3[a]
CON60	69.3 ± 15.7	90.6 ± 19.4[a,b]	94.8 ± 24.6[a]	103.7 ± 25.8[a]
ECC60	80.1 ± 15.7[c]	102.1 ± 21.5[a,b,d,e]	109.3 ± 21.3[a,b,d,f]	121.3 ± 21.3[a,d,g]
ECC150	84.5 ± 18.9[c,f]	102.5 ± 17.5[a,e,h,i]	114.1 ± 27.8[a,c,g,h]	128.7 ± 29.3[a,c,g]
Quadriceps peak torque, Nm				
CON60	167.8 ± 29.4	182.1 ± 34.8	182.4 ± 33.4	191.1 ± 46.3
ECC60	220.0 ± 57.1[g]	222.4 ± 60.4[f]	225.2 ± 56.5[f]	225.6 ± 78.9[e]
ECC150	211.6 ± 52.3[f]	221.0 ± 66.3[e]	224.9 ± 58.6[f]	220.4 ± 75.1
Hamstrings-to-quadriceps ratio				
Hamstrings$_{con60}$:quadriceps$_{con60}$	0.41 ± 0.04	0.50 ± 0.06[j]	0.52 ± 0.07[j]	0.55 ± 0.08[j]
Hamstrings$_{ecc60}$:quadriceps$_{con60}$	0.48 ± 0.08[k]	0.56 ± 0.06[h,j,k]	0.60 ± 0.09[j,l]	0.65 ± 0.10[j,l]
Lateral hamstrings root mean square, μV				
ISO	215.7 ± 77.8	225.7 ± 103.9[b]	194.9 ± 94.3	160.6 ± 76.2
CON60	285.8 ± 141.7[d]	239.6 ± 102.1	218.8 ± 105.0	219.1 ± 122.1[d]
ECC60	214.2 ± 105.7[e]	198.4 ± 86.5	194.7 ± 85.2	161.5 ± 62.9
ECC150	193.2 ± 66.4[f]	176.9 ± 46.5[e]	171.4 ± 105.7[e]	160.7 ± 73.3[e]
Medial hamstrings root mean square, μV				
ISO	263.1 ± 122.9	230 ± 54.5	203.3 ± 88.3	166.4 ± 46.5
CON60	240.0 ± 84.1	219.1 ± 73.3	215.9 ± 78.3	184.0 ± 24.2
ECC60	235.2 ± 140.4	215.0 ± 115.3	177.4 ± 73.3	197.0 ± 55.9
ECC150	206.1 ± 110.1	160.2 ± 72.2	174.5 ± 113.8	188.0 ± 64.0

Abbreviations: CON60 indicates maximal concentric knee flexion-extensions of the right leg at 60° per second; ECC60, maximal eccentric knee flexion-extensions of the right leg at 60° per second; ECC150, maximal eccentric knee flexion-extensions of the right leg at 150° per second; ISO, maximal isometric hamstrings contraction of the right leg at 45° of knee flexion.

[a] Indicates different from 0° ($P < .001$).
[b] Indicates different from 90° ($P < .05$).
[c] Indicates different from ISO ($P < .001$).
[d] Indicates different from ISO ($P < .05$).
[e] Indicates different from CON60 ($P < .05$).
[f] Indicates different from CON60 ($P < .01$).
[g] Indicates different from CON60 ($P < .001$).
[h] Indicates different from 90° ($P < .01$).
[i] Indicates different from ISO ($P < .01$).
[j] Indicates different from 0° ($P < .01$).
[k] Indicates different from hamstrings$_{con60}$:quadriceps$_{con60}$ ($P < .05$).
[l] Indicates different from hamstrings$_{con60}$:quadriceps$_{con60}$ ($P < .01$).

muscular variables at a hip-flexion angle of more than 60° is relevant because it corresponds with the actual position of the joint at the time when hamstrings activity and resistance are critical (ie, at the end of the swing phase of the sprinting legs). Our study showed that for both angular velocities (60° and 150° per second), eccentric peak torque of the hamstrings was higher in a stretched and lengthened position than in a shortened one. In other words, when the hip is flexed, hamstrings are lengthened and develop more eccentric torque. Researchers know that skeletal muscle fibers have an optimal length to produce the largest contraction force; it is neither too long nor too short. A muscle fiber increases its contraction force when stretched to its optimal length, beyond which it loses several actin-myosin bridges and the potential force generated decreases.[30] When stretched even farther, passive structures start to play a major role and increase their tensile force. Net tensile force of the muscle fiber is the sum of tensile forces in passive structures and the force of muscle-fiber contraction. Equally for each condition, our results showed that the hamstrings muscle can produce the largest knee-flexor torque when it is lengthened through additional hip flexion. At the largest hip flexion (90°), we observed that the hamstrings muscle-tendon complex was not lengthened beyond the physiologic optimal length because torque did not decrease compared with lower levels of hip flexion.

For all conditions, we observed no difference in quadriceps peak torque between different hip-flexion positions. These results contrast with those of Worrell et al,[26] who observed that concentric contractions at 60°, 180°, and 240° per second induced larger quadriceps peak torque when the hip was at 110° of flexion than at 10°. Our results are in line with those of Bohannon et al[23] who reported no difference in concentric quadriceps peak torque at 60° per second from 30° to 85° of hip flexion. We think that this lack of influence of hip-flexion angle could be explained by the fact that the quadriceps muscle is predominantly monoarticular (except for the rectus femoris), but the hamstrings muscle is biarticular. Thus, hip flexion influences to a lesser extent the passive stretch component of the quadriceps and, consequently, the torque level during knee extension.

The finding that hamstrings and quadriceps peak torques in ECC60 and ECC150 were greater than in ISO and CON60 was expected. The finding that hamstrings and quadriceps peak torques in ECC60 and ECC150 were greater than in ISO and CON60 was expected. They were also similar between ECC60 and ECC150. This is in line with the literature; the torque-velocity relationship for hamstrings eccentric contractions generally shows no or little difference in strength among different angular velocities. For example, Higashihara et al[31] reported no differences among hamstrings eccentric peak torques at 60°, 180°, and 300° per second.

We also showed that hip position influences both the H_{con60}:Q_{con60} ratio and the H_{ecc60}:Q_{con60} ratio. These results are consistent with those of Worrell et al,[26] who suggested that hip flexion was a confounding factor in the H:Q ratio assessment similar to the angular velocity or the contraction mode.[27] Because we found that hip angle directly influenced hamstrings but not quadriceps peak torque, we were not surprised to find that hip position also influenced H:Q ratio. These findings suggest that a specific hip-flexion position should be used to assess H:Q ratio, and such a standardized hip flexion would allow reliable interindividual comparison of this ratio. Therefore, to be specific for sprinting biomechanics, we propose standardizing the hip angle at 80° of flexion during the H:Q ratio assessment (Figure A[a–c]).

One other part of our investigation included EMG activity measurements during the trials. We reported that the amount of hip flexion does not influence medial and lateral hamstrings EMG activity. This is consistent with the findings of Mohamed et al,[25] whereas Lunnen et al[24] showed greater hamstrings EMG activity at a larger hip-flexion angle. We believe that the lack of greater EMG signal with hip flexion points to the involvement of passive components to enhance hamstrings peak torque in this stretched position.

Researchers have shown that eccentric strengthening induces a shift in the length-tension relationship of muscle fibers[19,22] and an increase in the number of serial sarcomeres.[32,33] To date, investigators studying the influence of eccentric strengthening (with either the Nordic hamstrings exercise or the yo-yo flywheel ergometer) on strength, H:Q ratio, or injury prevention have not mentioned hip-flexion angle. Actually, these exercises were performed at a nonspecific angle, which does not correspond with the actual position at the end of the swing phase in sprinting.[18,20]

Our findings are of interest in injury prevention. Indeed, controlling hip flexion from 70° to 80° during a hamstrings eccentric strengthening program would positively influence sarcomere length, bring additional effects on the passive components of the muscles, and provide a more adequate strengthening stimulus. Such strengthening of the lengthened hamstrings could be beneficial for injury prevention because we know that hamstrings tears mainly affect the passive components, such as the myotendinous junction or the epimysium.[34]

In practice, using a hamstrings strengthening device functioning with a hip-flexion angle greater than 60° might have additional potential benefits. Greater weight loads could be applied during knee flexion when using this type of device than when using a device without hip flexion, such as the lying hamstrings curl. We believe that optimal hamstrings strengthening for injury-prevention purposes should include the following features: on the one hand, an eccentric component with the hip flexed at the sprint-specific angle of 80° to 90°, in which position a higher peak torque can be generated and which would allow higher loads during training (greater resistance to knee flexion), and on the other hand, a concentric component because we have shown greater EMG activation of the LH in CON60 than ECC150. Therefore, combining concentric and eccentric stimuli during hamstrings strength training would be more effective in maintaining a high level of muscle innervation.

Moreover, our protocol might be used as a screening tool. Investigators could conduct studies in which the results of an established hamstrings strength test procedure for athletes in these positions and at these speeds could be compared with their injury rates and types over the course of a season. If predictive test results can be found for injury risk, specific preventive measures and strengthening exercises should be introduced. The speed of contraction and the strength at end-range elongation also are relevant predictors of hamstrings strains. However, for clinical use, we think that evaluating peak torque is more convenient for assessing how strength is influenced by hip-flexion angle and whether test results are a good predictor of injury risk.

In future studies, it would be interesting to assess how an eccentric strength-training program that includes this specific hip-flexion angle (70° to 80°) and peak torque as an identified risk factor for injury influences the angle of peak torque.[35] Even if this eccentric program already has been shown to effectively increase the angle of peak torque[21] and decrease injury rates,[18,36,37] we believe that it could be more effective if hip flexion was incorporated, which would add positive effects on passive hamstrings components.

Our study had some limitations. First, we did not test high-velocity eccentric contraction due to technical constraints. The Biodex System 2 only allowed us to assess a velocity up to 150° per second in eccentric mode. However, as mentioned, hamstrings peak torque does not change for velocities from 60° to 300° per second.[31] Second, participants were positioned with both hips at the same angular position, which is not what happens during the late swing phase of the running cycle. In addition, the pelvis of each participant was positioned in more posterior tilt than occurs during running, which would have reduced the lengthening stretch of the hamstrings during the tests. Third, we chose not to randomize the hip positions between the 2 sets. This did not seem to influence our results. In fact, values of peak torques and H:Q ratios at 30° and 90° of hip flexion were coherent with those at 0° and 60°. Although we noted no difference between hamstrings peak torques at 60° and 30° of hip flexion, we found a trend toward higher values at the higher hip flexion. Fourth, given a relatively large standard deviation, the interpretation of RMS data is debatable. In our view, EMG results are relevant as a control variable, showing that muscle activation is not different. Fifth, one of our participants had a hamstrings strain about 2 years before the study. We cannot exclude that an inadequate rehabilitation could have negatively affected the hamstrings peak torque assessment for this participant.

CONCLUSIONS

Hip-flexion angle influenced hamstrings peak torque in isometric, concentric, and eccentric isokinetic contractions. As hip flexion increased, hamstrings peak torque and H:Q ratio increased. This suggests that the H:Q ratio norms should be defined for a given hip angle. In addition, the efficiency of hamstrings-strengthening exercises could be improved by controlling hip angle. Whether a newly defined eccentric resistance-training program at a sprint-specific hip-flexion angle (70° to 80°) can better prevent hamstrings injuries in sprinters remains to be addressed, but our results lead us to believe that the perspective is worthwhile.

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