

Observational Study

Acute effects of static stretching on peak and end-range hamstring-to-quadriceps functional ratios

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Abstract

AIM: To evaluate if static stretching influences peak and end-range functional hamstring-to-quadriceps (H/Q) strength ratios in elite women athletes.

METHODS: Eleven healthy female athletes in an elite competitive level participated to the study. All the participants fulfilled the static stretching or non-stretching (control) intervention protocol in a randomized design on different days. Two static unassisted stretching exercises, one in standing and one in sitting position, were used to stretch both the hamstring and quadriceps muscles during these protocols. The total time for the static stretching was 6 ± 1 min. The isokinetic peak torque measurements for the hamstring and quadriceps muscles in eccentric and concentric modes and the calculations for the functional H/Q strength ratios at angular velocities of $60^\circ/s$ and $180^\circ/s$ were made before (pre) and after (post) the control or stretching intervention. The strength measurements and functional strength ratio calculations were based during the entire- and end-range of knee extension.

RESULTS: The pre-test scores for quadriceps and hamstring peak torque and end range values were not significantly different between the groups ($P > 0.05$). Subsequently, although the control group did not

exhibit significant changes in quadriceps and hamstring muscle strength ($P > 0.05$), static stretching decreased eccentric and concentric quadriceps muscle strength at both the 60°/s and 180°/s test speeds ($P < 0.01$). Similarly, static stretching also decreased eccentric and concentric hamstring muscle strength at both the 60°/s and 180°/s test speeds ($P < 0.01$). On the other hand, when the functional H/Q strength ratios were taken into consideration, the pre-intervention values were not significantly different between the groups both during the entire and end range of knee extension ($P > 0.05$). Furthermore, the functional H/Q strength ratios exhibited no significant alterations during the entire and end ranges of knee extension both in the static stretching or the control intervention ($P > 0.05$).

CONCLUSION: According to our results, static stretching routine does not influence functional H/Q ratio. Athletes can confidently perform static stretching during their warm-up routines.

Key words: Elite women athletes; Eccentric; Concentric; Static stretching; Functional hamstring-to-quadriceps ratio; Muscle strength

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Core tip: Despite the well-known effects of static stretching on muscle strength its effects about the characteristics of injury risk have not been investigated thoroughly. Functional hamstring-to-quadriceps (H/Q) strength ratio that reflects imbalance in thigh muscle strength is one of the etiologic risk factors for sports injuries. There are few studies in the literature investigating the relationship between static stretching and injury risk characteristics. The results of this study demonstrate that static stretching does not influence the functional H/Q ratio. Hereby, our findings also show that static stretching does not increase the risk for injury.

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INTRODUCTION

It is often deemed that enhancing joint range of motion or flexibility with stretching routines will promote greater sporting ability by improving muscular performance and possibly reducing the risk of musculoskeletal injury^[1,2]. Dynamic, static, proprioceptive neuromuscular facilitation, and ballistic stretching are the usually performed techniques of stretching^[1]. Because of the safe and easy application, static stretching is the widely preferred method^[1]. Recently, however, some studies

have indicated temporary compromises in the ability of various muscles to generate isometric or isokinetic strength following pre-exercise static stretching^[3-8]. This is noteworthy for athletes participating in sport activities demanding on high force and strength production. Accordingly, some authors have recommended to exclude static stretching during warm-ups due to the probability of hindering performance during competition^[5,8]. On the other hand, there is little evidence about the role of static stretching as a preventive component to reduce the risk of musculoskeletal injury^[9-11].

It has been suggested that thigh muscle imbalance between the quadriceps and hamstring muscles is a potential mechanism for increased injury to the lower extremities^[12]. Although there are a variety of measurement techniques, the hamstring-to-quadriceps (H/Q) ratio has been used in both clinical and laboratory research as a balance of strength indicator about muscles around the knee joint, as it reflects the relationship between two contrary muscle groups, the agonist and antagonists, and provides a thorough description of reciprocal muscle function^[13,14]. Previous authors have suggested that the agonist-antagonist strength relationship may be better described by a functional knee flexion/knee extension (KF/KE) ratio of eccentric hamstring to concentric quadriceps muscle strength (ECC_{KF}/CON_{KE}) rather than the conventional ratios that are often used (CON_{KF}/CON_{KE})^[13,15]. It was shown that such reciprocal muscle group ratios provide information on knee function, injury risk and knee joint stability^[16]. Any imbalance in the functional ratio implicates a predisposing factor towards injury^[17,18]. Interestingly, when the ECC_{KF}/CON_{KE} ratio was less than 0.6 at 60°/s the probability of a hamstring muscle injury in elite soccer players was 77.5%^[19]. Similar results were demonstrated by Yeung *et al.*^[20]. If the pre-season hamstring to quadriceps ratio was lower than 0.6 at 180°/s angular velocity the risk of hamstring injury was 17 times higher in competitive sprinters^[20]. Studies have reported that injury, detraining or training might have impacts on the changes of normal reciprocal strength distribution around the knee joint^[21,22]. Few studies have investigated the impacts of static stretching during the pre-participation training routine on these strength ratios, and those data that are available are conflicting^[23,24]. Recently, Costa *et al.*^[24] showed that static stretching decreases functional H/Q muscle strength ratio. Besides, Ayala *et al.*^[23] could not demonstrate any adverse effects of static stretching on conventional and functional strength ratios. Strength ratios in both studies were calculated based on the peak moment obtained during the entire range of knee extension and flexion^[23,24]. However, since the antagonist muscles are more important during the end range of motion to decelerate limb movement and the functional dynamics of the knee are better approximated during end ranges, functional strength ratio in the end range of knee extension and/or flexion also seems to be functionally relevant.

The purpose of the present study was to investigate the effects of static stretching of both the quadriceps and

hamstring muscles on peak and end range functional H/Q strength ratios in elite women athletes.

MATERIALS AND METHODS

Subjects

Eleven healthy Caucasian females participated to this observational study. The mean value for age was 21 ± 2 years, for height was 166 ± 7 cm, and for weight was 59 ± 7 kg. All volunteers participated to sports activities in an elite competitive level and were members of National Athletic clubs. The sport activities the subjects were regularly involved were triple jump, hammer throw, high jump, heptathlon, 100 m hurdles, and middle- and long-distance track events. Team coaches and athletes declared that their training backgrounds they had regularly trained for were on average 11 ± 3 h per week for 8 ± 2 years. The test procedure assessed the dominant leg, which was the right leg for all subjects. The leg that the subjects used to kick a ball was determined as the dominant leg. Subjects were excluded from the study if they had a recent or current ankle-, knee-, hip-, or lower back-related injury, had previously complained of functional limitations, swelling, or pain in these joints or had previous apparent knee range of motion limitations. The subjects were informed about the study context and test procedures, and any likely risks and discomfort that might arise. Thereafter, all subjects read and signed the informed-consent form that had been approved by the University's Institutional Ethical Board for Protection of Human Subjects, which also approved the study.

Experimental procedure

Before initiating the experiments, the subjects were invited to the laboratory to give them information about the test procedure they need to know. Furthermore, to be familiar with the testing they participated to the isokinetic knee strength measurements in eccentric and concentric modes at the chosen angular velocities. To remind, when the tension on a muscle fiber increases as it shortens, it is called as concentric muscle contraction. On the other hand, when the tension on a muscle fiber increases as it lengthens, it is called as eccentric muscle contraction. When the subjects visited the laboratory for the second time, they performed the protocols for stretching intervention, non-stretching (control) and static stretching, in a randomized order on different days within one week. The isokinetic peak torque measurements for the hamstring and quadriceps muscles in eccentric and concentric modes and the calculations for the functional H/Q strength ratios were made before (pre) and immediately after (post) the stretching interventions. A five-minute warm-up at 50 W was performed by each subject using a stationary cycle ergometer before the first isokinetic testing. The static stretching procedure took approximately 6 ± 1 min. Therefore, to be similar, the subjects rested for five minutes in a supine or sitting position in the non-

stretching (control) period.

Static stretching exercises

The hamstring and quadriceps muscles of the dominant lower extremity were stretched with two unassisted static stretching exercises. Each unassisted static stretching routine, which comprised of two consecutive repetitions, was held for 20 s to the level the subject represented mild discomfort with no pain. The rest interval between the two repetitions and the static stretching exercises of the hamstring and quadriceps muscles was 15 s. Consequently, all the stretching routine took 6 ± 1 min totally. Although the common recommendation about performing stretching exercises for longer periods of time, we choose the given time because athletes actually carry this amount of stretching time before sport activities. The hamstring and quadriceps muscles were stretched statically in sitting and standing positions. A detailed description of the same quadriceps (Figure 1) and hamstring (Figure 2) static stretching exercises in standing and sitting positions used in this study has been published previously by Sekir *et al.*^[7].

Isokinetic testing

The hamstring and quadriceps isokinetic peak torque (PT) in eccentric and concentric modes were measured with the Cybex NORM isokinetic dynamometer (Lumex, Inc., Ronkonkoma, New York, United States) The calibration of the dynamometer was executed according to the regular equipment maintenance schedule for this testing device^[25].

After positioning the tested knee on the extension-flexion plate of the Cybex NORM system, Velcro straps were used to secure the knee key to the instructions of the manufacturer for isolating knee extension and flexion^[25]. The dynamometer was adjusted temper to the length of the knee joint of each subject. The chest and lower part of the thigh was stabilized by placing strapping across them, and placements were limited to grasping the waist stabilization strap. Range of motion was set between 10° and 90° knee range of motion angles (0° indicating full knee extension). In order to be familiar with the testing device, subjects were advised to execute three active repetitions of knee movement ranging from 90° to 10° knee range of motion before the testing session began. All the tests were performed by the same investigator for standardization. The investigator advised the subjects to exert 100% effort and gave them favourable feed-back during testing. Peak torque measurements for the eccentric and concentric modes were performed one by one; the concentric measurement was performed firstly. In order to familiarize the subjects with the test conditions, they conducted three submaximal contractions of the hamstring and quadriceps muscles before the test condition. Thereafter, they were then instructed to perform four maximal contractions at the test speeds of $60^\circ/s$ and $180^\circ/s$ angular velocities. Same angular velocities were valid for the eccentric strength measurement as in the concentric

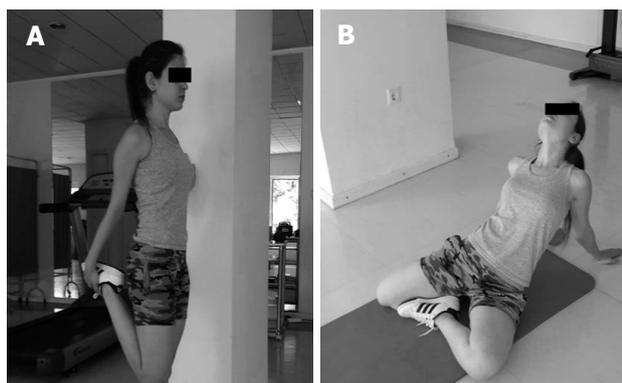


Figure 1 The two types of static stretching exercise for the quadriceps muscle (A in standing and B in sitting position).

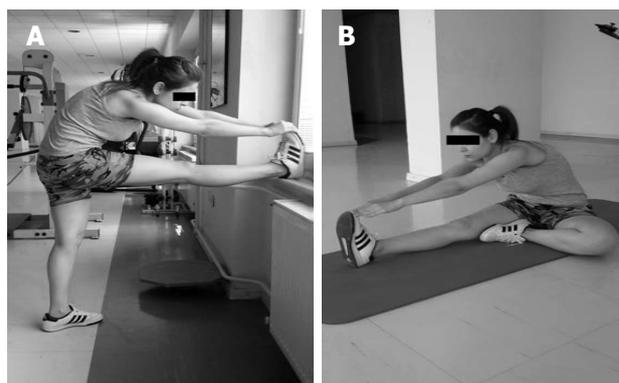


Figure 2 The two types of static stretching exercise for the hamstring muscle (A in standing and B in sitting position).

measurement. Each of the tests (60°/s and 180°/s) were separated with a one-minute rest, and the concentric and eccentric measurements were separated with a minimum of a three-minute rest to hinder the build-up of fatigue. The best PT of the four maximal contractions for each test condition during the entire range of motion and end range of knee extension and flexion (see below) was collected and used in the functional H/Q muscle strength ratio analysis.

Functional hamstring/quadriceps muscle strength ratio

Hamstring to quadriceps muscle functional strength ratio was calculated based on the peak moment obtained during the entire range of knee extension and flexion (90° to 10° and 10° to 90°, respectively). In addition, since the antagonist muscles are more important during the end range of motion to decelerate limb movement, we also calculated the functional ratio in the end range of knee extension (30° to 10°). This was also done to better approximate the functional dynamics of the knee. The maximal eccentric hamstring peak torque was divided by the maximal concentric quadriceps peak torque to determine the functional H/Q strength ratio (ECC_{KF} / CON_{KE}).

Statistical analysis

SPSS version 10.0 software (SPSS Inc., Chicago, IL, United States) was used for the statistical analysis. All variables were described with means and standard deviations. All tests were two-tailed and the level of significance was set at $P < 0.05$. The statistical review of the study was performed by associate professor Deniz Sigirli from Department of Biostatistics, Uludag University Faculty of Medicine.

Non-parametric statistical testing was chosen because of the limited number of subjects included in this study and non-normally distributed data. Normality was tested with Shapiro-Wilks test. A power analysis was performed based on the reported values of the study. According to the analysis, group sample sizes of $n_1 = n_2 = 11$ achieved 98% power to detect a mean difference = 0.07 and standard deviations of both

groups = 0.04 with a significance level (alpha) of 0.05.

Statistical differences between the groups [non-stretching (control) and static stretching] pre-intervention test scores and percent change values of the variables following the intervention were investigated using Mann-Whitney U test. Percent change values for each variable were calculated as: $[(\text{post-intervention} - \text{pre-intervention}) / \text{pre-intervention}] \times 100$. In addition, the statistical differences within the groups between pre- and post-stretching were investigated using Wilcoxon's signed rank test.

RESULTS

Strength

The mean peak torque values and the mean values during the end range of knee extension for the eccentric and concentric strength of the hamstring and quadriceps muscle in the static stretching and control group are represented in Tables 1 and 2. The quadriceps and hamstring peak torque and end range values were not significantly different between the groups before the stretching intervention ($P > 0.05$). As shown in Figure 3A and Table 1, static stretching significantly decreased quadriceps muscle strength in eccentric and concentric modes at 60°/s and 180°/s test speeds ($P < 0.01$), whereas the values showed no change following the control condition ($P > 0.05$). Similar to the changes in the quadriceps muscle strength, static stretching also induced a significant reduction ($P < 0.01$) in the hamstring muscle strength (Figure 3B and Table 2), with no changes seen after the non-stretching control condition ($P > 0.05$).

Functional ratio

Table 3 present the functional H/Q strength ratios during the entire and end range of knee extension in the two groups. As presented in the Table, no significant pre-intervention group differences were existent, both for the entire and end-range knee extension ($P > 0.05$). There were also no significant stretching intervention effects on the functional H/Q strength ratios for either

Table 1 Peak and end range muscle strength of the quadriceps before and after stretching intervention (mean ± SD)

	Control		Static	
	Before	After	Before	After
ConPT60 (Nm)	226 ± 49	223 ± 51	229 ± 49	210 ± 52 ^b
ConPT60-ERE (Nm)	145 ± 46	148 ± 46	160 ± 43	136 ± 36 ^b
ConPT180 (Nm)	134 ± 29	133 ± 28	131 ± 29	119 ± 28 ^b
ConPT180-ERE (Nm)	103 ± 26	102 ± 26	104 ± 27	89 ± 24 ^b
EccPT60 (Nm)	266 ± 79	269 ± 76	273 ± 76	246 ± 70 ^b
EccPT180 (Nm)	234 ± 66	236 ± 63	246 ± 56	224 ± 51 ^b

^bP < 0.01 (following stretching). Ecc: Eccentric; Con: Concentric; PT: Peak torque; ERE: End-range of knee extension; Nm: Newton-meter; 60: 60°/s angular velocity; 180: 180°/s angular velocity.

Table 3 Functional hamstring-to-quadriceps muscle strength ratios for knee extension during the entire and end range before and after stretching intervention in the two groups (mean ± SD)

	Control		Static	
	Before	After	Before	After
ER-Ext-60	1.10 ± 0.28	1.09 ± 0.26	1.00 ± 0.32	1.07 ± 0.41
ER-Ext-180	1.51 ± 0.40	1.54 ± 0.38	1.54 ± 0.61	1.51 ± 0.60
Ext-60	0.70 ± 0.17	0.72 ± 0.14	0.72 ± 0.16	0.71 ± 0.18
Ext-180	1.21 ± 0.27	1.21 ± 0.24	1.25 ± 0.39	1.20 ± 0.36

ER: End range; Ext: Extension; 60: 60°/s angular velocity; 180: 180°/s angular velocity.

group (*P* > 0.05, Figure 4 and Table 3).

DISCUSSION

Despite the well-known effects of static stretching on muscle strength^[3-8], its effects about the characteristics of injury risk have not been investigated thoroughly. Given that static stretching results in acute strength decrements of a specific musculature, only 2 studies^[23,24] to date (to our knowledge) have examined the relationship between static stretching and injury risk characteristics through the measurement of an imbalance in thigh muscle strength (deducted from functional H/Q strength ratio). However, both studies exhibited contradictory results; Costa *et al.*^[24] displayed decreases in functional H/Q ratios, whereas Ayala *et al.*^[23] stated that static stretching routines have no adverse effects on functional hamstring to quadriceps ratios. Hereby, the aim of the current study was to evaluate the acute influence of static stretching on functional H/Q ratios. Briefly, besides the significant individual decrements in hamstring and quadriceps muscle strength, static stretching exercises of the knee flexor and extensor muscles did not alter the functional hamstring to quadriceps strength ratios during the entire range of motion and end range of knee extension in elite women athletes.

Studies have reported that assessing the H/Q strength ratio and antagonist co-activation may contribute to identification of normal knee function and

Table 2 Peak and end range muscle strength of the hamstring before and after stretching intervention (mean ± SD)

	Control		Static	
	Before	After	Before	After
ConPT60 (Nm)	150 ± 34	152 ± 34	157 ± 32	145 ± 29 ^b
ConPT180 (Nm)	105 ± 22	106 ± 23	110 ± 26	101 ± 23 ^b
EccPT60 (Nm)	161 ± 52	160 ± 47	162 ± 44	144 ± 42 ^b
EccPT60-ERE (Nm)	156 ± 53	157 ± 48	155 ± 50	139 ± 48 ^b
EccPT180 (Nm)	161 ± 44	161 ± 43	162 ± 49	139 ± 44 ^b
EccPT180-ERE (Nm)	154 ± 47	155 ± 46	156 ± 56	132 ± 50 ^b

^bP < 0.01 (following stretching). Ecc: Eccentric; Con: Concentric; PT: Peak torque; ERE: End-range of knee extension; Nm: Newton-meter; 60: 60°/s angular velocity; 180: 180°/s angular velocity.

muscle balance with which pathological states can be compared^[26]. By this way, the causes of hamstring and knee injuries might be explained, and *via* correcting training and rehabilitation athletic trainers might develop a preventive approach^[14]. Aagaard *et al.*^[13,15] suggested that a more functional ratio calculated by dividing eccentric strength of the hamstrings by the concentric strength of the quadriceps may better describe the capacity for muscular knee/joint stabilization compared with the traditional conventional (CON_{KF}/CON_{KE}) ratio. In fact, an eccentric contraction of the hamstring muscle (the stabilizer) combines the concentric action of the quadriceps muscle (the prime mover) during knee extension. When the knee joint approaches maximum knee extension, the shear and rotation of the tibia is counteracted by this co-activation of knee flexor muscles^[13,15]. The reason for this co-activation is the increase of the posterior pull and joint stiffness and reduction of anterior laxity force in order to oppose the force of the quadriceps loading^[27]. This helps to prevent overextension, decelerating the leg before knee reaches full extension and stabilizing the knee joint throughout the range of motion^[27]. In other words, a strain may occur if the hamstring does not lengthen sufficiently during extension of the knee and/or is relatively weaker than the quadriceps. Therefore, useful information is provided by the assessment of eccentric strength of the antagonist muscles relative to the concentric strength of the agonist muscles to describe the maximal capacity of the antagonist muscles. This could be more practical in detection an injury risk in comparison to the conventional H/Q strength ratio. Conversely, it is possible that the antagonist co-activation is more important at the end range of motion in order to control limb movement. To control for this, we calculated the functional H/Q strength ratio at the end ranges of knee extension (30°-10°), as well as during the entire range.

When the functional H/Q strength ratio for knee extension was taken into consideration, the ratio obtained from the peak torque values during the entire range of motion before the intervention was 0.70 and 0.72 at low angular velocity (60°/s) and 1.21 and 1.25 at high angular velocity (180°/s) for the control and static stretching groups, respectively. These ratios did not

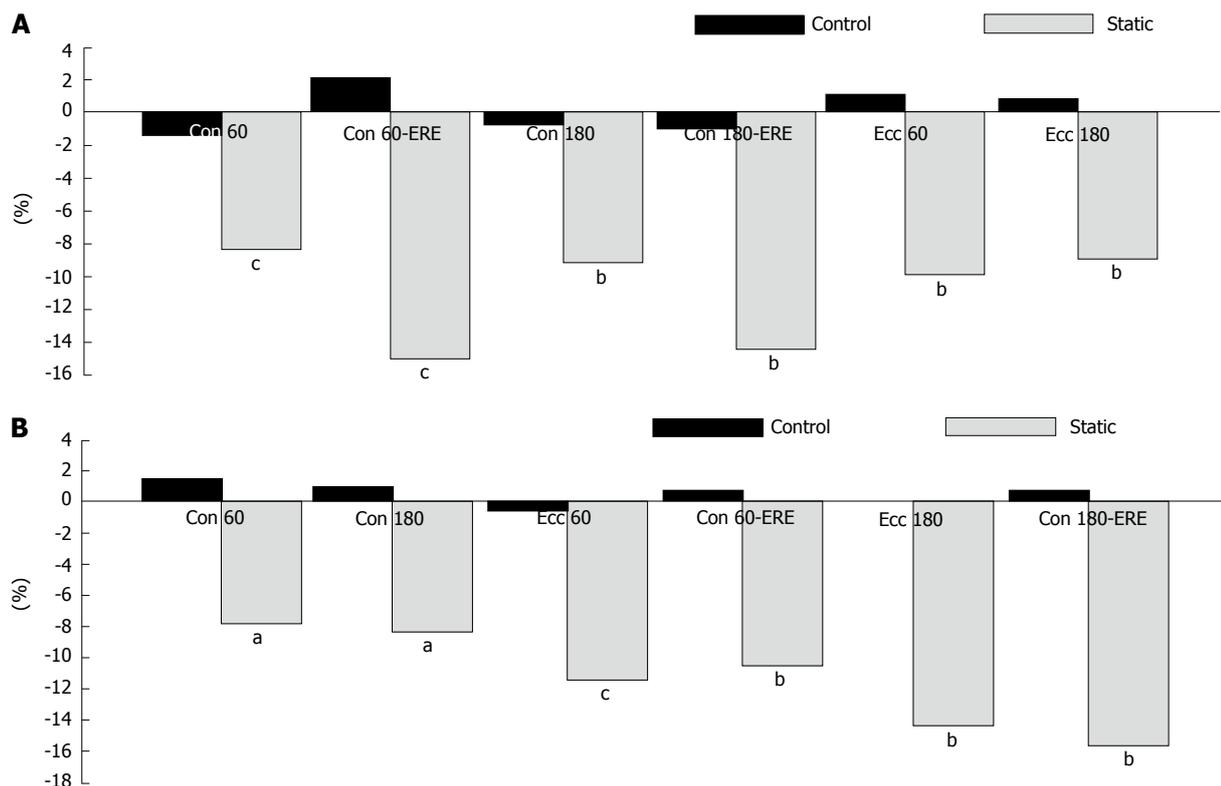


Figure 3 Changes in percentage (%) following stretching intervention for peak and end range torque measurements of the quadriceps muscle (A) and the hamstring muscle (B). Ecc: Eccentric; Con: Concentric; ERE: End-range of knee extension; 60: 60°/s angular velocity; 180: 180°/s angular velocity. (^a*P* < 0.05, ^b*P* < 0.01, ^c*P* < 0.001).

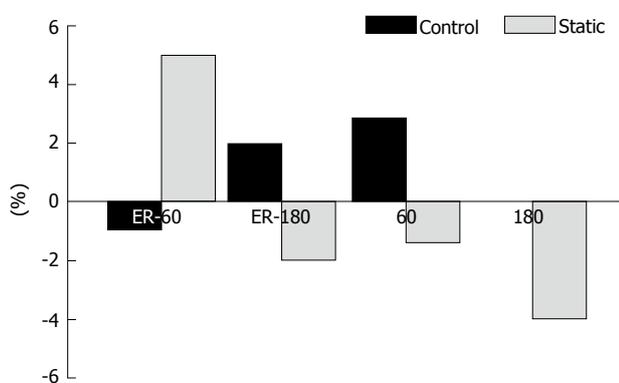


Figure 4 Changes in percentage (%) following stretching intervention for functional hamstring-to-quadriceps muscle strength ratios for knee extension during entire and end range of motion. ER: End range; 60: 60°/s angular velocity; 180: 180°/s angular velocity.

significantly change after the intervention (values were 0.72 and 0.71 at 60°/s and 1.21 and 1.20 at 180°/s for control and static stretching groups, respectively). Static stretching, therefore, did not alter the functional H/Q strength ratios, in contrast to observations reported in previous studies for individual muscle strength performance. Our results suggest that static stretching performed in a pre-participation warm-up routine does not increase injury risk characteristics. Similarly, Ayala *et al.*^[23] indicated also that static lower-limb stretching routines do not alter the relative risk of hamstring strains by reducing the functional H/Q ratio. Following

static stretching the ratio at 60°/s (stretching = 0.69 and control = 0.70) and 180°/s (stretching = 0.88 and control = 0.89) angular velocities displayed same values as the no-stretching control session. In contrast, Costa *et al.*^[24] reported a significant reduction of 7%-11.5% in the functional H/Q ratio at angular velocities of 60°/s and 180°/s following a session of quadriceps and hamstring static stretching. A possible explanation could be that Costa *et al.*^[24] used an extensive overall stretch duration of 36.5 min, whereas the current study stretched the hamstrings and quadriceps muscles for approximately 6 min, which represents more the typical warm-up preferred by athletes and recreationally active people before competition or exercise. Nevertheless, further research in this area is still necessary to address the injury risk features that follow static stretching.

The functional H/Q strength ratios in our study are consistent with those reported in previous studies that calculated the functional ratio for knee extension during the entire range^[15,22,28-33]. Besides, the functional H/Q strength ratios reported in our study were higher for the end ranges of knee extension (1.0-1.10 for 60°/s and 1.51-1.54 for 180°/s) than during the entire range of knee extension. Similar results were obtained from the few studies that calculated this ratio at the end ranges of extension^[15,34]. Aagaard *et al.*^[15] signified that the functional H/Q strength ratio increases at more extended knee joint positions. Their results displayed an increase from 0.6 to 1.0 for 30°/s and from 1.0 to

1.4 at the end ranges of knee extension. The functional H/Q strength ratios from the study of Kellis *et al.*^[34] were also higher (2.2 for 60°/s and 2.7 for 180°/s) for corresponding end ranges (30°-10°). Based on the measurements of peak moments from the entire and end ranges of knee extension, the functional H/Q ratios of 1.20 to 1.25 presently observed for fast knee extension (180°/s) suggests an equal or greater magnitude of capacity of the hamstring muscle to brake the action of the maximal quadriceps knee extension moment. Additionally, knee joint stabilization effect by the muscles was progressively increased when knee joint positions were gradually more extended, as indicated by the values of 1.51 to 1.54 observed at the end ranges of knee extension (30° to 10°). This was also valid for the slow angular test velocity (60°/s). The functional H/Q ratio for the entire range was 0.70-0.72, and increased to approximately 1.0-1.1 as the end ranges were approached. It is possible that this trend may help prevent hyperextension of the knee and reduce anterior displacement of the tibia on the femur when necessary. Our higher ratios obtained at the end range supports the idea that, in a typical movement, the agonist muscles produce the main force for the movement and the antagonist activity is higher at the initial and final phases of the movement to decelerate the limb and control the joint^[35]. Osternig *et al.*^[36] represented a sharp increase in eccentric hamstring activation during the last 25° of a concentric knee extension. The values reported for the functional H/Q ratios appeared to be consistent with the contractile force to length properties of the agonist-antagonist muscle synergies about the knee joint. It has been shown that the knee extensors peak moments occur at knee angles of approximately 60°-70°, whereas 20°-30° was the ranges where knee flexors generated peak moments^[13]. Furthermore, concentric quadriceps moment decreases from 90° of knee flexion to 0° (full extension) throughout the range of motion and the eccentric hamstring moment displays a relative constant behaviour, yielding an increase in the ratio as a full knee extension is approached^[15]. The high functional hamstring to quadriceps strength ratios observed for knee extension at end ranges are the result of the relationships of contractile force to muscle length and thus peak moment. At the end range of knee extension, the hamstring muscles approach their optimal length and peak moment, whereas the length to tension conditions of the quadriceps muscles are increasingly compromised.

It is generally thought that static stretching decreases individual muscle strength. Therefore, suggestions were made to omit static stretching during pre-participation routines in order to prevent a negative influence on performance. Our study shows that functional hamstring to quadriceps strength ratios do not change following a static stretching routine. Hereby, our findings also show that static stretching does not increase the imbalance between the quadriceps and hamstring muscles. The take home message for the practitioner is that elite women athletes not involved in sports mainly based

on sheer power like wrestling, weightlifting or power lifting can confidently perform static stretching during warm-up. Eventually, these results should be considered by women athletes who perform static stretching exercises for both the hamstring and quadriceps muscles before athletic events.

COMMENTS

Background

Despite the well-known effects of static stretching on muscle strength its effects on injury risk characteristics have not been investigated in depth. There are few studies in the literature investigating the relationship between static stretching and injury risk characteristics through the measurement of an imbalance in thigh muscle strength [deducted from functional hamstring-to-quadriceps (H/Q) strength ratio].

Research frontiers

Those data that are available about the effects of static stretching on functional H/Q strength ratio are conflicting. Additionally, strength ratios in the previous studies were calculated based on the peak moment obtained during the entire range of knee extension. However, since the antagonist muscles are more important during the end range of motion to decelerate limb movement and the functional dynamics of the knee are better approximated during end ranges, functional strength ratio in the end range of knee extension and/or flexion also seems to be functionally relevant.

Innovations and breakthroughs

To evaluate the functional H/Q strength ratio before (pre) and after (post) the intervention, the maximal eccentric hamstring moment was divided by the maximal concentric quadriceps moment. Finally, the authors could not find any differences in functional H/Q strength ratios following the static stretching routine.

Applications

These results demonstrate that the functional H/Q ratio does not change following a static stretching routine. Hereby, the findings show that static stretching does not increase the imbalance between the quadriceps and hamstring muscles.

Terminology

Static stretching means a stretch is held in a challenging but comfortable position for a period of time, usually somewhere between 20 to 30 s. Concentric muscle contraction is a type of muscle activation that increases tension on a muscle fiber as it shortens. Eccentric muscle contraction is a type of muscle activation that increases muscle tension on a muscle fiber as it lengthens. Functional H/Q strength ratio is the maximal eccentric hamstring moment divided by the maximal concentric quadriceps moment.

Peer-review

This is an interesting pilot type study with a lot of potential for future research.

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