ORIGINAL ARTICLE

Decrease in eccentric hamstring strength in runners in the Tirol Speed Marathon

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Background: The local muscular endurance of knee flexors, during eccentric work in particular, is important in preventing or delaying kinematic changes associated with fatigue during treadmill running. This result, however, may not be transferable to overground running.

Objective: To test the hypothesis that overground running is associated with eccentric hamstring fatigue.

Methods: Thirteen runners (12 male and one female) performed an isokinetic muscle test three to four days before and 18 hours after a marathon. Both legs were tested. The testing protocol consisted of concentric and eccentric quadriceps and hamstring contractions.

Results: There were no significant differences between peak torque before and after the race, except that eccentric peak hamstring torque (both thighs) was reduced.

Conclusion: Overground running (running a marathon) is associated with eccentric hamstring fatigue. Eccentric hamstring fatigue may be a potential risk factor for knee and soft tissue injuries during running. Eccentric hamstring training should therefore be introduced as an integral part of the training programme of runners.

Regular physical activity is important for health and has been linked to a reduced risk of numerous chronic diseases.¹ The most common adverse consequence of physical activity is the risk of musculoskeletal injury.² Studies from Scandinavia document that sports injuries constitute 10–19% of all acute injuries seen in emergency departments, and the most common types are knee and ankle injuries.³ Thus effective prevention efforts are needed to reduce the risk for these injuries.² Recent results suggest that a structured warm up programme to improve running, cutting, and landing techniques as well as neuromuscular control, balance, and strength can prevent knee and ankle injuries in young people playing team handball.⁴ However, further studies are needed to determine what the key component(s) of the programme are in reducing risk of injury, and it seems warranted to examine the physiological effects of each programme component on injury risk.⁴ In this way it may be possible to develop even more specific programmes that require less time and effort and may be suitable for “weekend recreational” athletes also.⁴

Running is one of the leading injury related activities for women and men aged ≥ 20 years.² The injury rate for runners is 46%, and the knee and foot are the most common locations of injury.⁵

Many recent epidemiological studies have suggested fatigue as a potential risk factor for athletic injuries.^{6,7} Muscle fatigue impairs not only performance, but also proprioceptive acuity and pre-activation of stabilising muscles.⁸ Negative or eccentric—that is, muscle lengthening—muscle work is regarded as an important component in maintaining balance and knee stability when performing precarious movements.^{9–11} Joint stability is determined by an interaction of passive restraints produced by the ligaments and other joint structures, joint geometry, friction between cartilage surfaces, and stability provided by muscles acting on the joint.¹² Of all these factors, the stability provided by the contracting muscles appears to be the most important for knee stability.⁸ Eccentric muscle action stabilises the knee

joint dynamically as eccentric muscle contraction acts to control deceleration of body segments during dynamic tasks.¹²

Moreover, the muscle generates much greater force during eccentric contractions than during concentric contractions,¹³ and the former are consequently more often related to muscular injury because of concurrent tension levels in the muscle.¹³ In addition, recent results suggest a relation between eccentric local muscular endurance of the hamstrings with changes in running mechanics.¹⁴ Eccentric hamstring fatigue may thus be a potential risk factor for knee injury during running. However, we were not able to find evidence that eccentric hamstring fatigue takes place during overground running. We therefore undertook the present study to test the hypothesis that overground running (running a marathon) is associated with eccentric hamstring fatigue.

METHODS

Study design

Three to four days before running a marathon, 16 subjects (14 male and two female runners) completed a survey designed to acquire baseline information and medical history, and performed an isokinetic muscle test. The latter was repeated by the 13 subjects who reported to the finishing line research station 18 hours after the end of the marathon. Their median (range) age was 41.0 years (23.0–54.0), and median (range) weight at the start of the race was 79.0 kg (61.1–89.1).

Subjects underwent electrocardiographic and physical examinations conducted by a doctor, provided blood samples for laboratory tests, and answered questionnaires administered by trained interviewers. All were healthy with no history of knee joint ligamentous trauma. They ran about four times a week, about six hours a week.

Written informed consent was given by all participants. The study protocol was approved by the ethics committee of the Medical University of Innsbruck.

Table 1 Peak hamstring and quadriceps torque in runners in the 2005 Tirol Speed Marathon

Muscle	Peak torque (N.m)		p Value
	Before race	After race	
Hamstring			
Concentric contractions			
Right thigh	105.2 (92.2–127.7)	101.2 (80.9–130.7)	0.1016
Left thigh	111.5 (87.5–130.6)	103.3 (83.9–126.7)	0.1763
Eccentric contractions			
Right thigh	127.7 (118.5–148.6)	117.7 (93.7–144.4)	0.0244
Left thigh	134.5 (120.7–174.6)	117.0 (93.7–136.1)	0.0122
Quadriceps			
Concentric contractions			
Right thigh	142.8 (111.0–177.9)	128.7 (84.9–158.8)	0.0830
Left thigh	156.6 (139.5–165.9)	137.9 (92.9–162.8)	0.0640
Eccentric contractions			
Right thigh	196.7 (163.2–205.6)	162.7 (144.0–192.0)	0.1475
Left thigh	189.2 (169.9–216.8)	167.3 (135.2–204.7)	0.1240

Values are median (range). Thirteen runners (12 male and one female) performed an isokinetic muscle test three to four days before and 18 hours after running a marathon. Only eccentric (muscle lengthening) peak hamstring torque (both thighs) was significantly different (reduced) after the race. p Values were determined by Wilcoxon test.

Isokinetic dynamometry

An isokinetic dynamometer (CON-TREX MJ; CMV AG, Zurich, Switzerland) was used to generate angle-torque curves. An angle-torque curve is a measure of the torque as a function of knee joint angle produced when the muscle is maximally activated during isovelocitly shortening or stretching. After warming up (10 minutes on a bicycle), subjects were seated on the CON-TREX MJ with their hip joint at about 90° flexion and their upper bodies secured with dual cross over straps as well as a waist strap. The range of motion at the knee was about 110°. The angle was 0° when the leg was fully extended at the knee and 110° when it was fully flexed. A thigh strap on the test leg was used to restrict any lateral movement at the knee, allowing only flexion and extension movements. Both legs were tested, and the testing protocol consisted of concentric and eccentric quadriceps and hamstring contractions (four repetitions each at an angular velocity of 60°/s). Torque and angle signals were transferred from the dynamometer to a computer and analysed. Optimum peak torque was recorded for hamstrings and quadriceps of both legs and used for statistical analysis.

Statistical analysis

A non-parametric Friedman analysis of variance was applied for assessment of time dependence. Paired Wilcoxon tests were used to assess the significance of changes in variables after the marathon compared with baseline. $p \leq 0.05$ was considered significant. Data in table 1 are given as medians and interquartile range (first quartile–third quartile).

RESULTS

Of the 16 runners enrolled, only 13 reported to the finishing line research station (one female runner and two male runners did not report). The median (range) duration of the marathon was 3 hours 43 minutes 50 seconds (3 hours 12 minutes 52 seconds to 4 hours 26 minutes 28 seconds). Interestingly, there were no significant differences between peak torque before and after the race, except eccentric peak hamstring torque (table 1).

DISCUSSION

It has recently been shown that the three most common sites of injury for masters runners are the knee (19.6%), foot (16.2%), and hamstring (11.7%).⁵ The most common injuries in younger runners are to the knee (24.8%), foot (16.2%), and leg (11.3%) (this was also referred to as the shin and included the area between the knee and the ankle, excluding the calf).⁵

Therefore knee injury should be a public health concern because it increases the likelihood of discontinuing regular physical activity and developing osteoarthritis.¹⁵ Regular physical activity is effective in maintaining good health and preventing the onset of chronic lifestyle diseases.¹ Consequently, stopping regular exercise puts people at increased risk of developing lifestyle related health problems. Research into knee injury causality and identification of risk factors that may predispose runners to knee injury may help in the development of knee injury prevention programmes⁴ to reduce injury prevalence and assist people to maintain active lifestyles.

Lower extremity muscle fatigue may increase the risk of knee and soft tissue injuries.^{2 5 14 16} The data from this study suggest that eccentric hamstring fatigue occurs in non-elite marathon runners (aged ≥ 20 years;² median age 41.0 years), which may put them at undue risk of knee injury^{5 14} and soft tissue injuries—for example, to the hamstrings.^{5 14} As far as we are aware, this is the first study to show eccentric hamstring fatigue during overground running.

A recent study suggests that the local muscular endurance of knee flexors, during eccentric work in particular, is important in preventing or delaying kinematic changes associated with fatigue during endurance running.¹⁴ Moreover, Westblad *et al*¹⁷ found that the eccentric local muscular endurance of the knee flexors in elite middle distance runners correlated with running economy. These studies, in common with most other studies, used treadmill running.¹⁴ It has been assumed in most studies that the

What is already known on this topic

- Eccentric local muscular endurance of the knee flexors correlates with running economy, and is important in preventing or delaying kinematic changes associated with fatigue during treadmill running

What this study adds

- This study is the first to show eccentric hamstring fatigue during overground running

results are transferable to overground running. Wank *et al*¹⁸ compared kinematics and electromyographic activity during treadmill and overground running and found that, during treadmill running, there was greater activity of the biceps femoris, and that this activity lasted longer during ground contact and the first part of the swing phase. Therefore, because of the greater activity of the hamstrings,¹⁸ we do not know if the results on treadmill running are transferable to the overground situation. Clearly, there is a need to update the literature and focus specifically on overground running. In this study, a key finding was the decrease in eccentric hamstring strength during overground running.

The practical implication from this finding and previous research¹⁴⁻¹⁷ is that monitoring eccentric hamstring muscle actions and exercise training would be one relatively simple strategy for reducing the risk of knee and soft tissue injuries in runners. For example, a prevention programme for runners could include a strength exercise, the "Nordic hamstring lower" exercise,⁴ that has been shown to be effective in improving eccentric hamstring muscle strength in adult male soccer players.¹⁹

Importantly, although it is possible that stronger hamstring muscles would prevent knee injury, this theory has never been tested.⁴ Further studies are needed to determine if stronger hamstrings reduce the incidence of knee and soft tissue injuries during running.

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COMMENTARY

The short term effects of running on the musculature of the lower limb are not well studied. This investigation shows that the shock absorption properties of the muscles of the lower limb may well be compromised by prolonged running. As the sample studied is of trained subjects, one wonders whether these negative effects would be more pronounced in untrained or less well trained subjects, and whether a cumulative effect would be possible.

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