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Original Research

Strength and endurance training reduces the loss of eccentric hamstring torque observed after soccer specific fatigue

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ABSTRACT

Objectives: To investigate the effect of two hamstring training protocols on eccentric peak torque before and after soccer specific fatigue.
Participants: Twenty-two university male soccer players.
Design: Isokinetic strength tests were performed at 60°/s pre and post fatigue, before and after 2 different training interventions. A 45-min soccer specific fatigue modified BEAST protocol (M-BEAST) was used to induce fatigue. Players were randomly assigned to a 4 week hamstrings conditioning intervention with either a maximum strength (STR) or a muscle endurance (END) emphasis.
Main outcome measures: The following parameters were evaluated: Eccentric peak torque (EccPT), angle of peak torque (APT), and angle specific torques at knee joint angles of 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80° and 90°.
Results: There was a significant effect of the M-BEAST on the Eccentric torque angle profile before training as well as significant improvements in post-fatigue torque angle profile following the effects of both strength and muscle endurance interventions.
Conclusions: Forty-five minutes of simulated soccer activity leads to reduced eccentric hamstring torque at longer muscle lengths. Short-term conditioning programs (4-weeks) with either a maximum strength or a muscular endurance emphasis can equally reduce fatigue induced loss of strength over this time period.

1. Introduction

Hamstring strain injuries (HSI) are one of the most common sporting injuries, accounting for 12%–26% of all injuries that occur in sprint dominated sports (Lysholm & Wiklander, 1987; Small, McNaughton, Greig, Lohkamp, & Lovell, 2009; Woods et al., 2004) and are a major cause of time lost to both training and competition (Bennell et al., 1998; Ekstrand, Hagglund, & Walden, 2011; Woods et al., 2004). In soccer, the majority of HSI occur under conditions of fatigue (Greig & Siegler, 2009; Small et al., 2009; Small, McNaughton, Greig & Lovell, 2010; Woods et al., 2004), primarily in the latter periods of a game or half (Rahnama, Reilly, Lees, & Graham-Smith, 2003; Small et al., 2009), such that 47% of HSI are sustained during the final 15 min of match play (Woods et al., 2004). In intermittent sprint sports such as soccer, declines in hamstring peak torque are observed, not only after 90 min of real or simulated soccer (Cohen, Bingnan, Okwera, Matthews, & Delextrat, 2015; Marshall et al., 2014; Small et al., 2010), but also as early as half-time (45 min into play) or after 45 min of simulated soccer (Hoff & Helgerud, 2004; Marshall et al., 2014).

Moreover, soccer-specific fatigue appears to promote preferential strength loss at longer muscle lengths (Cohen et al., 2015), angles at which deficits are associated with injury. Cohen's study observed these changes to the torque angle profile after a 90 min fatiguing protocol, however, it is unknown whether these changes might also occur sooner. Although there is an observed increase in injury risk at the end of a soccer half (Ekstrand et al., 2011; Woods et al., 2004), and a previously observed decline in eccentric hamstring torque after 45 mins (Small et al., 2010), it is unknown

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whether 45 min of soccer specific fatigue is also associated with a change in the torque angle profile.

With the changes to the eccentric torque and torque angle profile observed in the hamstrings under conditions of fatigue (Cohen et al., 2015; Delextrat, Gregory, & Cohen, 2010, 2013), and the higher incidence of HSI observed under conditions of fatigue (Orchard, Seward, Orchard, & Driscoll, 2013; Woods et al., 2004), the training of muscular endurance, as well as maximum strength, of the hamstrings may be helpful within an injury prevention program. Even with the previous success of strength training protocols for decreasing the incidence of HSI (Arnason, Andersen, Holme, Engebretsen, & Bahr, 2008; Mjolsnes, Arnason, Osthagen, Raastad, & Bahr, 2004; Van der Horst, Wouter Smits, Petersen, Goeghart, & Backx, 2014), it is not known whether these strength protocols have any influence on preserving eccentric muscle strength under conditions of fatigue. Moreover, it is also not known whether endurance based protocols will have any influence on eccentric muscle strength under conditions of fatigue. It therefore seems prudent to investigate the effects of both endurance training (low load/high repetition) as well as strength training (high load/low repetition) protocols on hamstring fatiguability.

The principle aims of this study were firstly to investigate the effect of a 45 min soccer specific fatiguing protocol (M-BEAST) on the torque angle profile of competitive soccer players. Secondly, we aimed to compare the effects of a high load/low repetition (maximum strength emphasis) and a low load/high repetition (muscular endurance emphasis) hamstring conditioning training intervention on eccentric hamstring torque and torque decline following the M-BEAST.

We hypothesised that 45 min of soccer specific activity will result in a significant reduction in eccentric hamstring strength. In addition, we hypothesised that a 4 week hamstrings conditioning intervention with either a high load/low repetition, maximum strength, emphasis or a low load/high repetition, muscle endurance, emphasis will positively influence eccentric hamstring strength under conditions of soccer specific fatigue.

2. Methodology

2.1. Participants

Twenty-two volunteers from the University soccer teams participated in this study. Of these, twenty completed the study. Participants were pre-screened with a physical activity readiness questionnaire (University of Salford, Human Performance Laboratory, PARQ) for any previous or current injuries and medical conditions that would impede their participation and those with present injuries, major operations and muscle or tendon injuries within the past year were excluded. Ethical approval was gained prior to the study from the institution's RGEC.

2.2. Procedures

All testing took place in the human performance laboratory of the University. Subjects participated in two testing days separated by a four week training block. On each occasion, players were assessed before and after a modified 45-min soccer-specific fatiguing protocol (M-BEAST) that is based on the Ball-sport Endurance And Sprint Test (BEAST90) (Williams, Abt, & Kilding, 2010) (Fig. 1). In order to optimise the range during which true isokinetic measures are collected and allow for more repeatable measures across a range of joint angles (Baltzopoulos, 2008), the KinCom isokinetic dynamometer was set to 60°/s (type, 125 AP, Chattanooga, TN, USA). The following parameters were evaluated: Eccentric peak torque (EccPT), angle of peak torque (APT), and angle specific torques at knee joint angles of 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80° and 90°. After the first testing session, participants were randomly allocated (using a systematic random sample based on alphabetical order of names) to either a strength training group (STR) ($n = 11$) or a muscle endurance training group (END) ($n = 11$). Two participants from the END group did not complete the experiment. Anthropometric data for both groups of are as follows. END ($n = 9$; 21.8 ± 2.8 years, 179.4 ± 6.5 cm and 79.3 ± 11.8 kg). STR ($n = 11$; 23.2 ± 3.8 years, 184.8 ± 8.4 cm and 82.5 ± 8.8 kg).

Participants were asked to avoid eating two hours prior to testing and to avoid any strenuous activity in the 48 h prior to assessment. Prior to the isokinetic test, a seven-minute continuous dynamic warm up was performed on the track in the human performance lab of the University. Testing was conducted on the dominant leg, defined as the leg most commonly used for kicking. Each participant was seated on the isokinetic dynamometer in 90° hip flexion and 90° knee flexion, with the range of 90° to 0° of knee extension set (Askling, Karlsson, & Thorstensson, 2003; Brockett, Morgan, & Proske, 2004). The lever arm was aligned with the knee joint line (parallel to lateral epicondyle) and the shin pad attached above the malleoli. The dynamometer was adjusted according to the participant's limb length, to ensure that their knee was overhanging the seat by two inches. Shorts were worn to aid visibility. Each participant's thigh, waist and torso were strapped to eliminate extraneous movement. To ensure consistency between tests the lever arm length (cm) and dynamometer settings were recorded for each participant and gravity correction was applied. Angular velocity was set at 60°/s. The participant was instructed to give maximal effort for three repetitions. All isokinetic testing was conducted by the same researcher who was trained and familiar with the equipment and blinded to the allocation of groups.

2.3. Reliability

Prior to the initial test session, all participants attended a familiarisation session with the isokinetic dynamometer, after which the repeatability of EccPT and APT was determined using intra-class correlation coefficient (model 2,1). The comparison of first and second measurements indicated a strong correlation between the two measures of 0.92 ($p < 0.01$) (EccPT) and 0.94 ($p < 0.01$) (APT). For the angle specific ICCs there was a strong correlation shown at 10° (0.92; $p < 0.01$), 20° (0.91; $p < 0.01$), 30° (0.88; $p < 0.01$), 40° (0.90; $p < 0.01$), 50° (0.89; $p < 0.01$), 60° (0.91; $p < 0.01$), 70° (0.92; $p < 0.01$), and 80° (0.91; $p < 0.01$).

2.4. Selection of exercise

Rehabilitation programs and training sessions that work on eccentric loading via Nordic Hamstring Curls (NHC) appear to have a positive effect in reducing both the risk and recurrence of HSI (Arnason et al., 2008; Brito et al., 2010; Haekkinen and Komi, 1985; Mjolsnes et al., 2004; Petersen, Thorborg, Nielsen, Budtz-Jørgensen, & Hölmich, 2011; Thorborg, 2012), with typical training protocols structured to bring about an improvement in eccentric strength, particularly at longer muscle lengths (Arnason et al., 2008; Askling et al., 2003; Brockett et al., 2004; Gabbe, Bennell, Finch, Wajswelner, & Orchard, 2006; Petersen et al., 2011).

However, although NHC appear to have a positive effect on muscle strength (Brito et al., 2010), and can decrease hamstring strains (Arnason et al., 2008; Mjolsnes et al., 2004), many athletes simply do not have enough strength to perform NHC to full range of motion under control, reaching a “break point” well before the angles at which hamstring injuries occur. In order to reach beyond these ranges, many trainers prescribe a form of “assisted” NHC involving the use of an elastic band to support the athlete and