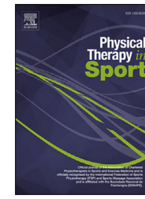
Physical Therapy in Sport 25 (2017) 47–54

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp



Original Research

The effects of a combined static-dynamic stretching protocol on athletic performance in elite Gaelic footballers: A randomised controlled crossover trial

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ARTICLE INFO

Article history:
Received 27 May 2016
Received in revised form
15 October 2016
Accepted 30 November 2016

Keywords:
Static-stretching
Dynamic-stretching
Gaelic football
Athletic performance

ABSTRACT

Objectives: To determine the effect of three different static-dynamic stretching protocols on sprint and jump performance in Gaelic footballers.
Design: Double-blind, controlled, crossover trial.
Setting: Sports Institute research environment.
Participants: Seventeen male elite level Gaelic footballers, aged 18–30 years, completed three stretching protocols.
Main Outcome Measures: Athletic performance was measured by countermovement jump height and power, and timed 10 m, 20 m, and 40 m sprints.
Results: Static stretching reduced sprint speed by 1.1% over 40 m and 1.0% over 20 m. Static stretching also reduced countermovement jump height by 10.6% and jump power by 6.4%. When static stretching was followed by dynamic stretching, sprint speed improved by 1.0% over 20 m and 0.7% over 40 m ($p < 0.05$). The static - dynamic stretching protocol also improved countermovement jump height by 8.7% ($p < 0.01$) and power by 6.7% ($p < 0.01$).
Conclusions: Static stretching reduces sprint speed and jump performance. Static stretching should be followed by dynamic stretching during warm-up to nullify any performance deficits caused by static stretching.

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1. Introduction

Gaelic Football is Ireland's national sport (McIntyre, 2005; Strudwick, Reilly, & Doran, 2002). The sport places a high demand on the aerobic system and other components of fitness including strength, agility, sprint endurance, flexibility and speed (McIntyre, 2005). Gaelic footballers carry out a large number of accelerations, decelerations, jumps and changes of direction in a 60–70 min game (O'Donoghue & King 2004). Muscle-tendon unit injuries account for 51.8% of all injuries in elite level Gaelic football (Murphy, O'Malley, Gissane, & Blake, 2012).

Athletes carry out pre-participation warm ups to prepare for the demands of the sport (Bishop & Middleton, 2013) and a well-designed warm-up can bring about physiological changes to optimise performance (Swanson, 2006). Traditionally warm-ups have consisted of a sub-maximal aerobic component followed by static stretching (Bishop, 2003) and a segment of skill rehearsal in which the athletes perform dynamic movements similar to those of the sport or event (Young, 2007). The aim of the sub-maximal aerobic component was to raise the body temperature. This increase in temperature has been found to increase nerve conduction velocity and increase muscle-tendon unit compliance (Bishop, 2003).

Static stretching has been shown to be an effective way of improving ROM (Bandy, Irion, & Briggler, 1997; Paradisis, Pappas, Theodorou, Zacharogiannis, Skordilis & Smirniotou, 2014; Power, Behm, Cahill, Carroll & Young, 2004; McHugh & Cosgrave, 2010). Static stretching has been traditionally part of sports warm-ups to help prevent injury (Ekstrand, Gillquist, & Liljedahl, 1983; Hadala & Barrios, 2009; Smith, 1994), reduce subsequent muscle soreness (High, Howley, & Franks, 1989) and improve performance (Beaulieu, 1981; Shellock & Prentice, 1985; Stamford, 1984; Young,

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http://dx.doi.org/10.1016/j.ptsp.2016.11.006
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2007; Young & Behm, 2003).

A review by McHugh and Cosgrave (2010) concluded that there was evidence that pre-participation stretching reduces the incidence of muscle strains. More recently a comprehensive review by Behm, Blazevich, Kay, and McHugh (2016), supported this point and concluded that static stretching shows no overall effect on all-cause injury or overuse injuries, but there may be a benefit in reducing acute muscle injuries in movements with repetitive contractions such as running and sprinting.

Various studies have found that static stretching may impair performance (Behm & Kibele, 2007; Behm, Bradbury, Haynes, Hodder, Leonard & Paddock, 2006; Nelson, Allen, Cornwell & Kokkonen 2001). A review by Shrier (2004) investigating the effect of stretching on performance found that 23 out of 24 studies reviewed reported that acute stretching reduced performances of force, torque production and jumping. Subsequent reviews by McHugh and Cosgrave (2010), Behm and Chaouachi (2011), Kay and Blazevich (2012), Simic, Sarabon, and Markovic (2012) have also concluded that static stretching may have a negative effect on many aspects of sports performance. The European College of Sport Sciences published a position statement (Magnusson & Renstrom, 2006), which concluded that there was firm evidence that an acute bout of stretching could diminish performance in tests requiring maximal muscle efforts.

Many theories have been hypothesized why acute muscle stretching may negatively affect performance, such as reducing tendon stiffness, forcing the muscle to work at shorter and weaker lengths (Fowles, Sale, & MacDougall, 2000; Nelson et al., 2001; Weir, Tingley, & Elder, 2005; Cramer, Housh, Weir & Johnson, 2005). However Behm et al. (2016) suggested changes in muscle length are unlikely to be an important mechanism influencing the force reduction after static stretching.

Changes in tendon stiffness has also been reported to influence electromechanical delay (Cresswell, Löscher, & Thorstensson, 1995; Waugh, Korff, Fath & Blazewich, 2013, 2014) and therefore reduce the rate of force production. Reductions in tendon stiffness are also thought to affect the rate of force development (Bojsen-Møller, Magnusson, Rasmussen, Kjaer & Aagaard, 2005; Waugh et al., 2013). Brooks, Zerba, and Faulkner (1995) proposed mechanical stretch imposed on the muscle–tendon unit could cause damage within the muscle itself, thus reducing contractile force capacity. No studies have been able to demonstrate muscle damage following static stretching (Behm et al., 2016). The review by Behm et al. (2016) theorized that a reduction in central (efferent) drive following static stretching may also affect force production and that emotional arousal may positively stimulate the central nervous system and reduce the potential negative effect of static stretching on performance.

Many studies have also reported no reduction in strength, power, or explosive muscular performance following static stretching (Bazett-Jones, Winchester, & McBride, 2005; Burkett, Phillips, & Ziuraitis, 2005; Cramer et al., 2005; Unick, Kieffer, Cheesman & Feeney, 2005). Some studies have even reported improvement in athletic performance following static stretching (O'Connor, Crowe, & Spinks, 2006; Gonzalez-Rave, Machado, Navarro-Valdivielso & Vilas-Boas, 2009; Haag, Wright, Gillette, & et al, 2010).

A Cochrane review of 12 studies by Herbert, de Noronha, and Kamper (2011) found that the performance of static stretching before or after exercise did not lead to reduction in delayed-onset muscle soreness in healthy adults. Due to several studies (Behm & Kibele, 2007; Behm et al., 2006; Nelson et al., 2001) and a review (Shrier, 2004) reporting the negative effects of static stretching on sports performance the American College of Sports Medicine's guidelines (ACSM 2010) suggested static stretching be removed as part of a warm-up routine and to only include cardiovascular work when strength or power was important to performance.

Despite the lack of definitive evidence on the effect of static stretching on injury prevention, its lack of effectiveness in the prevention of muscle soreness and its detrimental effect on performance, static stretching continues to be a component to many warm-ups (Behm et al., 2016).

In more recent years there has been a shift away from static stretching and dynamic stretching has become a popular component to sporting warm ups (Behm et al., 2016). Dynamic stretching has been demonstrated in various studies to reduce injury (Arnason, Anderson, Holme & Englebretson, 2008; Manoel, Harris-Love, Danoff & Miller, 2008; Soligard et al., 2008) and improve subsequent athletic performance (Holt & Lambourne, 2008; Nelson & Kokkonen, 2001; Yamaguchi, Ishuu, Yamanaka & Yasuda, 2008). Hough, Ross, and Howatson (2009) and Torres et al. (2008) have suggested the performance enhancement may be to post-activation potentiation in the stretched muscle caused by voluntary contractions of the antagonist muscle. Post-activation potentiation is the phenomenon by which the contractile history of muscles directly affects their subsequent rate of force development (RFD) or the ability to generate force in a rapid manner (Hodgson, Docherty, & Robbins, 2005).

Dynamic stretching can elevate core temperature (Fletcher & Jones, 2004). Elevated core temperature could then increase nerve conduction velocity, muscle-tendon unit compliance and enzymatic cycling, accelerating energy production (Bishop, 2003). Dynamic stretching has also been suggested by some authors to increase central drive (Guissard & Duchateau, 2006). Murphy, Di Santo, Alkanani, and Behm (2010) demonstrated the ROM gains achieved with static stretching are maintained when dynamic activities are performed after the static stretching. Samson, Button, Chaouachi, and Behm (2012) found static stretching following a submaximal warm up to increase ROM more than dynamic stretching following a submaximal warm up.

The quality of evidence investigating the effect of stretching on athletic performance varies greatly. Most studies use a randomised crossover design. However some studies fail to employ tester-blinding (Sayers, Farley, Fuller, Jubenville & Caputo, 2008, Winchester, Nelson, Landin, Young & Schexnayder, 2008; Beckett, Scheiker, Wallman, Dawson & Guelfi, 2009; Gelen, 2010). Young (2007) concluded that there were contradictory results regarding the effects of acute stretch, which could have resulted from major issues in research design. Issues identified by Young (2007) included a lack of control or reliability analysis and the long, practically irrelevant durations of the imposed stretches, which did not typically reflect stretching durations carried out in pre-participation warm-ups. The total duration of muscle stretching in most studies in this area was much longer than the ranges normally used in practice i.e., 15–30 s per muscle group (Rubini, Costa, & Gomes, 2007; Young, 2007).

One criticism of the design method employed by studies investigating combined stretching and performance is the sequencing of the stretching protocols. Some studies instructed their participants to perform dynamic stretching then static stretching (Fletcher & Anness, 2007; Gelen, 2010). In sport, stretching techniques can typically be done in the reverse order, static stretching then dynamic stretching followed by sports specific drills (Behm & Chaouachi, 2011; Behm et al., 2016; Young, 2007).

Several studies have demonstrated when dynamic stretching was performed prior to static stretching there was no negative effect on subsequent performance (Beckett et al., 2009; Fletcher & Anness, 2007; Wallman, Mercer, & Landers, 2008; Winchester et al., 2008). A thorough search of the literature failed to uncover

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