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Running related gluteus medius function in health and injury: A systematic review with meta-analysis

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ABSTRACT

Running is a popular sport and recreational physical activity worldwide. Musculoskeletal injuries in runners are common and may be attributed to the inability to control pelvic equilibrium in the coronal plane. This lack of pelvic control in the frontal plane can stem from dysfunction of the gluteus medius. The aim of this systematic review was therefore to: (i) compile evidence of the activity profile of gluteus medius when running; (ii) identify how gluteus medius activity (electromyography) varies with speed, cadence and gender when running; (iii) compare gluteus medius activity in injured runners to matched controls. Seven electronic databases were searched from their earliest date until March 2015. Thirteen studies met our eligibility criteria. The activity profile was mono-phasic with a peak during initial loading (four studies). Gluteus medius amplitude increases with running speed; this is most evident in females. The muscles' activity has been recorded in injured runners with Achilles tendinopathy (two studies) and patellofemoral pain syndrome (three studies). The strongest evidence indicates a moderate and significant reduction in gluteus medius duration of activity when running in people with patellofemoral pain syndrome. This dysfunction can potentially be mediated with running retraining strategies.

1. Introduction

Running is an increasingly popular recreational and competitive sport that is associated with many cardiovascular and musculoskeletal benefits. In 2009–2010, over 1.1 million Australians (6.5% of the population) participated in running or jogging as a form of exercise and this was a significant jump in participation from 5 years earlier (0.68 million, 4.3% of the population) (Australian Bureau of Statistics, 2010). In 2013, over 50 million Americans participated in running or jogging, a rise of 5% since the previous year (Running USA, 2014). Although the benefits of physical activity are well documented, musculoskeletal injuries are common in runners of all levels. A recent meta-analysis indicates that the incidence of running related injuries per 1000 h of training is 17.8% for novice runners and 7.7% for recreational runners (Videbæk et al., 2015). Such injuries can affect not only the ability to participate in physical and occupational activity, but also affect the psychological wellbeing of the athlete (Leddy et al., 1994; Putukian, 2016).

Hip adduction excursion during running has been identified as a risk factor for the development of running related injuries such as patellofemoral pain syndrome (PFPS) (Neal et al., 2016). Arguably, gluteus medius (GMed) is one of the most important hip muscles that controls this coronal plane motion. It is morphologically suited to generate the large abduction torques required to maintain femoropelvic equilibrium in the coronal plane (Dostal et al., 1986; Flack et al., 2014). It is feasible then that GMed dysfunction may contribute to poor coronal plane pelvic control, or increased hip adduction excursion while running and contribute to injury. Some studies have associated hip muscle strength (Niemuth et al., 2005) or GMed activation (Willson et al., 2011) with running related injuries, however, there are no studies that systematically compile evidence of GMed function while running in those who are healthy or injured.

Neuromotor function is typically assessed using electromyography (EMG) (Basmajian and De Luca, 1985). Surface or fine-wire electrodes can record the resultant output of myoelectric activity from the central nervous system to a muscle for a particular task (Basmajian and De Luca, 1985; Konrad, 2005). It is known in some injuries that the timing and amplitude of EMG activity differs to that of uninjured groups (e.g. lateral epicondylalgia; Heales et al., 2016). A greater understanding of impairments in GMed EMG

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function when running may therefore assist in the development of targeted strategies for managing running related injuries (Willy and Davis, 2013). It could also help to guide approaches to minimise soft tissue injury risk in runners, of which there is currently no proven exercise based intervention (Yeung et al., 2011). Informed decisions on tailored intervention strategies may also be guided by an understanding of how GMed function varies between genders, running speed and cadence (Chumanov et al., 2008, 2012). The aim of this systematic review was therefore to identify the electromyographic (EMG) characteristics of GMed in healthy and injured runners. Specifically, we aimed to;

i. compile evidence of the GMed EMG activity profile when running,
ii. identify how GMed EMG amplitude and timing of activity varies between gender, cadence and speed of running,
iii. compare GMed EMG activity of injured runners to healthy matched controls and pool evidence with a meta-analysis (if appropriate).

2. Methods

2.1. Search strategy

MEDLINE, EMBASE, CINAHL, SPORTDiscus, AMED, PEDro and the Cochrane Library databases were searched from inception until week 2 March 2015. The search was performed using three main concepts (Appendix A); gluteals, running and electromyography. The search yield was exported to Endnote V.X6 (Thomson Reuters). Reference checking of included articles and citation tracking via Google Scholar were performed to identify relevant articles not initially detected.

2.2. Selection criteria

Studies were eligible if they reported on healthy participants, or compared healthy participants to an injured sample. To be included, studies were required to assess muscle activation in running on even land (either treadmill or overground; excluding cutting manoeuvres, obstacles or stairs). Sprinting related studies were not the primary focus of this review, however, were included if they were compared to running related speeds. All studies were required to use EMG as a primary tool to detect muscle activation. All experimental designs published in English language were included with the exception of case studies, narrative reviews and systematic reviews.

Two reviewers independently applied the selection criteria to the titles and abstracts of the yield (RN and AS reviewed studies with lead author A-M; RN and TP reviewed papers with lead authors N-Z). Any disagreement was referred to the third independent reviewer for consensus (AS for papers N-Z; or TP for papers A-M). Full texts were obtained from remaining articles for further consideration of eligibility.

2.3. Methodological quality

A standardised quality assessment tool recommended by the Non-Randomised Studies Group of the Cochrane Collaboration was adapted for this review (Ganderton and Pizzari, 2013; Siegfried et al., 2005). Risk of bias in non-randomised studies can be categorised in the following dimensions; selection bias, performance bias, detection bias, attrition bias and reporting bias (Reeves et al., 2008). Items relating to performance bias (typically associated with intervention based research) and reporting bias (difficult to quantify (Higgins and Altman, 2008)) were removed from this tool. The ratings for each study were used to rate the quality of the body of evidence.

2.4. Data extraction

One author (RN) independently extracted the relevant data from the included studies and this was checked by a second reviewer (AS). Information extracted included the condition and comparison, participant demographics, running protocol and specific EMG data including electrode placement and the method of processing. Temporal and/or amplitude EMG data for GMed was also extracted.

2.4.1. Running activity profile

Ensemble curves were compiled to provide an overall estimate of the major bursts, peaks and troughs of GMed throughout the gait cycle during running. To create the ensemble graph from included studies, the x-axis was time normalized to 100 points, representing foot contact (0%) and the subsequent ipsi-lateral foot contact (100%) of one complete stride. Amplitude values were then visually determined from magnified images of figures within an included study at 1% increments along the x-axis using GraphClick software (Arizona-Software, 2008; http://www.arizona-software.ch/graphclick/), and expressed as a per cent of peak amplitude across the gait cycle (Yang and Winter, 1984).

2.4.2. Effect of gender, cadence, speed and injury

To investigate the effect of gender, cadence, speed (e.g. running vs sprinting) and injury, an effect size estimate was generated from information within included studies. For between group, cross-sectional studies (e.g. comparing gender or injured and uninjured groups) a standardised mean difference (SMD = mean difference/pooled SD) and 95% confidence interval (95% CI) was calculated to determine the magnitude of difference in running related EMG activity between groups (Centre for Evaluation & Monitoring, n.d.). For repeated measures designs (e.g. effect of change in cadence or speed) a standardised paired difference (SPD, or repeated measures Cohen's d) with 95% CI was calculated using the Comprehensive meta-analysis Version 2 statistical software package (Biostat Inc., USA) (http://www.meta-analysis.com/) (Borenstein et al., 2009). Where the pre-test post-test correlation (r) was not reported or unable to be imputed, a conservative estimate of r = 0.5 was used (Borenstein et al., 2009; Negrin et al., 2012). Effect sizes of 0.2, 0.5 and 0.8 were considered small, medium and large respectively (Cohen, 1988).

2.5. Data synthesis

Data were grouped according to outcome (e.g. cadence) and described qualitatively. Where sufficient data were available from multiple comparative studies (e.g. injury vs control), SMDs were pooled in a meta-analysis using fixed or random effects (Review Manager 5.3), depending on statistical heterogeneity. I^2 values of 25%, 50% and 75% indicated low, moderate and high levels of heterogeneity (Higgins et al., 2003). A random effects analysis was conducted where moderate and high heterogeneity existed ($I^2 > 50\%$).

2.6. Assessment of the quality of the body of evidence

The Grades of Research, Assessment, Development and Evaluation (GRADE) approach was used to evaluate the quality of evidence in each meta-analysis (Guyatt et al., 2008; M.B. Schache et al., 2014). Quality was defined as high, moderate, low or very low (Balshem et al., 2011).