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Systematic review

Relationship between foot pain, muscle strength and size: a systematic review

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Abstract

Background Foot pain is common and disabling and thought to be associated with muscle weakness. Understanding the relationship between pain and weakness may help identify effective treatment targets.
Objectives To conduct a systematic review to evaluate the relationship between foot pain and foot muscle weakness, or muscle size as a proxy for weakness.
Data sources Electronic databases and reference lists were searched for all years to April 2015.
Eligibility criteria Full-text articles were retrieved based on the question 'Does the study evaluate an association between foot pain and foot muscle weakness or size?'
Data extraction and synthesis Two reviewers independently screened eligible studies, extracted data and completed a methodological rating.
Results Eight studies were identified evaluating the relationship between foot pain and foot muscle strength ($n = 6$) or size ($n = 2$). Four studies reported a significant relationship between pain and toe flexor force. One study reported a significant relationship between heel pain and reduced forefoot muscle size. One study reported an inconsistent association depending on measurement technique. One study reported no association between pain and hindfoot muscle size. One study reported no association between low to moderate pain and toe flexion force.
Limitations Due to data heterogeneity, no data were pooled for meta-analysis.
Conclusion There is evidence of a significant association between foot pain and muscle weakness when foot pain is of high intensity and primarily measured by toe flexion force. However there is inconsistent evidence that lower intensity foot pain is associated with other measures of foot muscle weakness or size.

Systematic Research Registry ID reviewregistry166.

Keywords: Pain; Foot; Muscle strength; Skeletal muscle weakness; Muscle size; Systematic review

Introduction

Foot pain has been reported to affect 14–42% of the adult population [1–3]. Foot pain is disabling and has been reported to compromise important day to day functional tasks such as walking, stair ascent and descent [4]. Both foot muscle weakness and foot pain can lead to poor balance as well as increasing the risk of falls in older adults [5]. Foot pain is associated with various foot deformities and pathologies that have also been linked to foot muscle weakness, such as hallux limitus, hallux valgus, and plantar fasciitis/plantar heel pain [6–10].

The cause–effect relationship between foot pain and foot muscle weakness is bidirectional. One theoretical model of pain-related inactivity has been largely based on the fear

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avoidance model [11]. While inactivity can cause reduced muscle strength, there are inconsistent links between inactivity or deconditioning among individuals with chronic pain relative to pain-free controls [12]. However, the opposite has also been proposed whereby weakness of muscles that assist in supporting the medial longitudinal arch of the foot may lead to excessive strain on other arch supporting structures, namely, the plantar fascia resulting in plantar heel pain [13]. Further, muscle weakness has also been associated with voluntary activation failure and poor antagonist co-activation in other clinical populations [14,15]. Overall, while there is a commonly held clinical opinion that muscle atrophy occurs in the presence of pain, the exact mechanism is complex and multifactorial.

Strength measures of the foot are commonly used clinically to assess toe flexion, ankle dorsiflexion and plantarflexion as well as foot inversion and eversion power. Devices used to measure foot strength include hand–hand dynamometry and similar strain gauges, load cells, plantar pressure systems and the paper grip test [16–20]. The validity and accuracy of these techniques are generally well-established [17,19,21].

However foot muscle strength is reliant on both intrinsic and extrinsic foot muscles, and due to the architecture of the foot and limitations of measuring techniques, the measurement of intrinsic strength in isolation is difficult, if not impossible [22]. Indeed toe flexor strength measures do not entirely differentiate between the force generated by the intrinsic and extrinsic foot muscles because many of the intrinsic and extrinsic muscles follow similar muscle lines of action and have adjacent insertions, particularly in the forefoot [18,23].

One alternative is the use of imaging to quantify muscle size, as a proxy measure of strength. Imaging the cross-sectional area (CSA) or volume of muscles can distinguish between the intrinsic and extrinsic foot musculature. Measuring muscle CSA or volume using MR imaging has been reported to be highly accurate and reliable [22,24]. Similarly, measuring CSA with real-time ultrasound of abductor hallucis, flexor hallucis brevis, flexor digitorum brevis, quadratus plantae and abductor digiti minimus muscles has also been reported as reliable [25]. However while imaging has been reported to have a high correlation with direct measures of muscle force, reduced muscle CSA cannot fully explain muscle weakness [26–28].

Given the high prevalence of unresolved chronic foot pain, the aim of this systematic review was to evaluate the relationship between foot pain and foot muscle weakness, as well as muscle size as a proxy for strength, to help identify potential targeted treatment approaches.

Methods

This systematic review was conducted according to the PRISMA statement [29].

Data sources and searches

A comprehensive search of electronic databases (MEDLINE, CINHAL, AMED, AgeLine, Scopus, SPORTDiscus, Web of Science) was conducted for all available papers to April 2015. The search strategy is available in online supplement Figure 1. Reference lists of all full text reviewed papers were hand-searched to identify any additional studies.

Study selection

Titles and abstracts of all identified records were assessed independently by two reviewers (PJL and EJN). Clearly ineligible papers were rejected from further analysis. Eligible full-text articles were retrieved for detailed evaluation according to the following screening question: 'Does the study examine or evaluate an association between foot pain and foot muscle weakness or size?' The exclusion hierarchy consisted of the following terms: duplicate or thesis, not an original study (review paper), no foot muscle weakness/strength measures, no foot pain measures, no association between foot muscles and pain reported (Online supplement Figure 2). Any inconsistencies regarding inclusion of studies were resolved by a third reviewer (CEH).

Data extraction and quality assessment

The following data were extracted independently by two reviewers (PJL and EJN): publication details (author, year), sample characteristics (age, gender, height, weight), inclusion and exclusion criteria, study methodology (study design, outcome measures, statistical tests) and results. Authors were contacted for incomplete data.

Studies were assessed for methodological quality using a modified Quality Index Tool [30] independently by two reviewers (PJL and EJN). Any disagreements remaining after a consensus meeting were resolved by a third reviewer (CEH). The Quality Index Tool has been shown to have high internal consistency and inter- and intra-rater reliability [30]. A subset of the Quality Index Tool was used, depending on whether the items were relevant to the type of study (Online supplement Figure 3). The original scale consists of 27 items. Nine items were ruled not applicable for the assessment of cross-sectional studies (items 4, 8, 13, 14, 17, 19, 23, 24 and 26) as they relate specifically to intervention studies. For single group studies a further three items were ruled not applicable (items 5, 21 and 22). Items 9 and 27 were considered not relevant for all studies (losses to follow up and power calculations) and were omitted from the study. The omitted items were removed from scoring. One item [20] assessing the validity and reliability of outcome measures was expanded into four separate items due to the variability of these measures and the subsequent effects on the accuracy of the outcomes. To allow comparisons between