Gait Deviations association with Plantar Heel Pain: A Systematic Review

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Introduction:

Plantar Heel Pain (PHP) has been identified as a common foot disorder that presents with significant pain and gait-related disability. Despite consensus that individuals with PHP have gait difficulty, there is not consensus on the gait dysfunctions most relevant to clinical management of PHP. Lack of clear evidence to support gait-related assessment and interventions may contribute to the limited use of gait in the evaluation and treatment of individuals with PHP. Evaluation of gait and gait training has proven to be successful in the management of other gait-related conditions and may be effective in the evaluation and treatment of individuals with PHP. The purpose of this systematic review was to identify relevant gait deviations associated with PHP.

Methods:

A systematic literature search was undertaken in August of 2014 using the electronic databases; CINAHL (1982 to present), MEDLINE (1966 to present), and Scopus (1823 to present). The keywords used for search criteria and the search strategy are outlined in **Fig 1**. Studies were included if it was available in English, contained participants over 18 years old with PHP, and assessed gait. Quality was assessed using a modified Downs and Black checklist and studies with a score higher than 74% were defined as high quality. This checklist has demonstrated high internal consistency, test-retest reliability, and interrater reliability[1]. Gait variables and findings were extracted from selected papers. Meta-analysis of extracted data was not possible due to heterogeneity of the methods used to measure gait characteristics, but conclusions were derived by considering results of all studies that examined the same gait characteristic. Level of evidence was determined from the number and quality of articles per gait characteristic[2].

Table 1.

Study	Sample Size	Downs and Black Score	Findings
Wearing et al (2007)[3]	10 w/ unilateral heel pain 10 matched asymptomatic	70.6%	▪ No difference in peak regional loading (ie, average peak vertical force (F) of rear, mid, forefoot, and digits) ▪ No difference in mean calcaneal-first metatarsal angle between symptomatic, asymptomatic, and control
Wearing et al (2009)[4]	9 w/ unilateral heel pain 9 matched asymptomatic	64.7%	▪ No difference in average heel loading stress rate, peak stress, time to peak stress, loaded & unloaded thickness, peak strain, or secant modulus (vs. control). Lower energy dissipation ratio (vs. control) ▪ No difference in initial foot-ground contact angle (vs. control) ▪ No difference in stance phase duration (vs. control) or combined rearfoot and midfoot phase duration (ie, 1st and 2nd rocker)
Wearing et al (2003)[5]	16 unilateral PF 16 matched asymptomatic	82.4%	▪ Total Foot: Lower second peak F in symptomatic (vs asymptomatic limbs). Delayed time to topic F minimum in symptomatic (vs control). No differences in first peak F or time to first peak F, topic F minimum, time to second peak F ▪ Regional Foot: Max F reduced in rearfoot (vs. asymptomatic and control) and forefoot (vs. control), increased in digital (vs. control). No difference in instant of max F at rear-, mid-, forefoot, or digits. Lower force-time integral (ie, impulse: COP) for the rearfoot (vs. asymptomatic & control); no diff in mid-foot, forefoot, or digits. ▪ No difference in stance phase duration between symptomatic, asymptomatic, and control
Harty et al (2005)[6]	15 longstanding PF 15 control	35.3%	▪ Decreased "contact" phase (ie, 1st rocker: 33%; rearfoot COP duration) and increased "forefoot" phase (ie, 3rd rocker: 55%) in PHP which was similar to controls walking with knee flexed 20 degrees
Wearing (2004)[7]	10 unilateral heel pain 10 matched asymptomatic	64.7%	▪ Increased max metatarsophalangeal (MPJ) angle (typically occurs in late stance) than controls in both symptomatic and asymptomatic limbs (ie, less MPJ dorsiflexion) ▪ No difference in max arch angle or range of arch movement in symptomatic, asymptomatic, or controls
Chang et al (2014)[8]	22 chronic PF 22 healthy controls	70.6%	▪ Lower peak vertical F at propulsion (ie, second peak F). No difference in peak impact Fs (ie, first peak F). ▪ Greater total rearfoot motion and trend towards greater max eversion velocity. No difference in initial contact rearfoot angle or max eversion during stance ▪ Greater max MPJ dorsiflexion in late stance ▪ Greater total plantar-dorsiflexion medial forefoot motion (vs. control), but no difference in max medial forefoot dorsiflexion, max eversion, or max abduction angle; no difference in total inversion-eversion motion.
Wearing et al (2002)[9]	16 unilateral PHP 16 matched asymptomatic	76.5%	▪ Lower force-time integral (ie, impulse; COP) at rearfoot (vs. asymptomatic & control), higher at midfoot (vs. control). No difference in forefoot. ▪ No difference in stance phase duration (vs. asymptomatic & control)
Kanatli et al (2001)[10]	59 unilateral or bilateral PHP (94 Feet) 47 asymptomatic (94 Feet)	58.8%	▪ No difference in peak pressure at initial contact (ie, heel strike)
Liddle et al (2000)[11]	23 unilateral PHP Asymptomatic limb used as control	70.6%	▪ No difference in total contact time (stance phase duration; vs. control)
Bedi et al (1998)[12]	40 w/ PF 40 matched control	82.4%	▪ Decreased force-time integral (non COP) at midfoot; increased at forefoot (vs. control). No difference at rearfoot.
Taunton et al (2002)[13]	267 PF cases	73.3%	▪ Greater than 50% had excessive pronation based on observational analysis
Wearing et al (2010)[14]	9 w/ unilateral plantar enthesopathy 9 asymptomatic matched	64.7%	▪ No difference in rearfoot force-time integral (COP-assumed; vs. control) ▪ Symptomatic limb energy dissipation ratio was much less than asymptomatic and control. No difference in peak stress, peak strain, or secant modulus in symptomatic, asymptomatic, or control. ▪ No difference in stance phase duration between symptomatic, asymptomatic, and control
Golightly et al (2014)[15]	98 w/ PF	94.1%	▪ Greater odds of plantar fasciitis if excessive supination in Caucasians
Huang et al (2010)[16]	50 w/ unilateral heel pain	78.6%	▪ Slower loading response COP velocity in symptomatic (vs. asymptomatic)
Kelly et al (1995)[17]	20 feet with chronic subtalar pain 30 asymptomatic controls	82.4%	▪ No difference in rearfoot or 1st, 3rd, 4th, 5th metatarsal peak pressures. Greater 2nd metatarsal peak pressure in symptomatic (vs. control) ▪ No difference in rearfoot contact duration

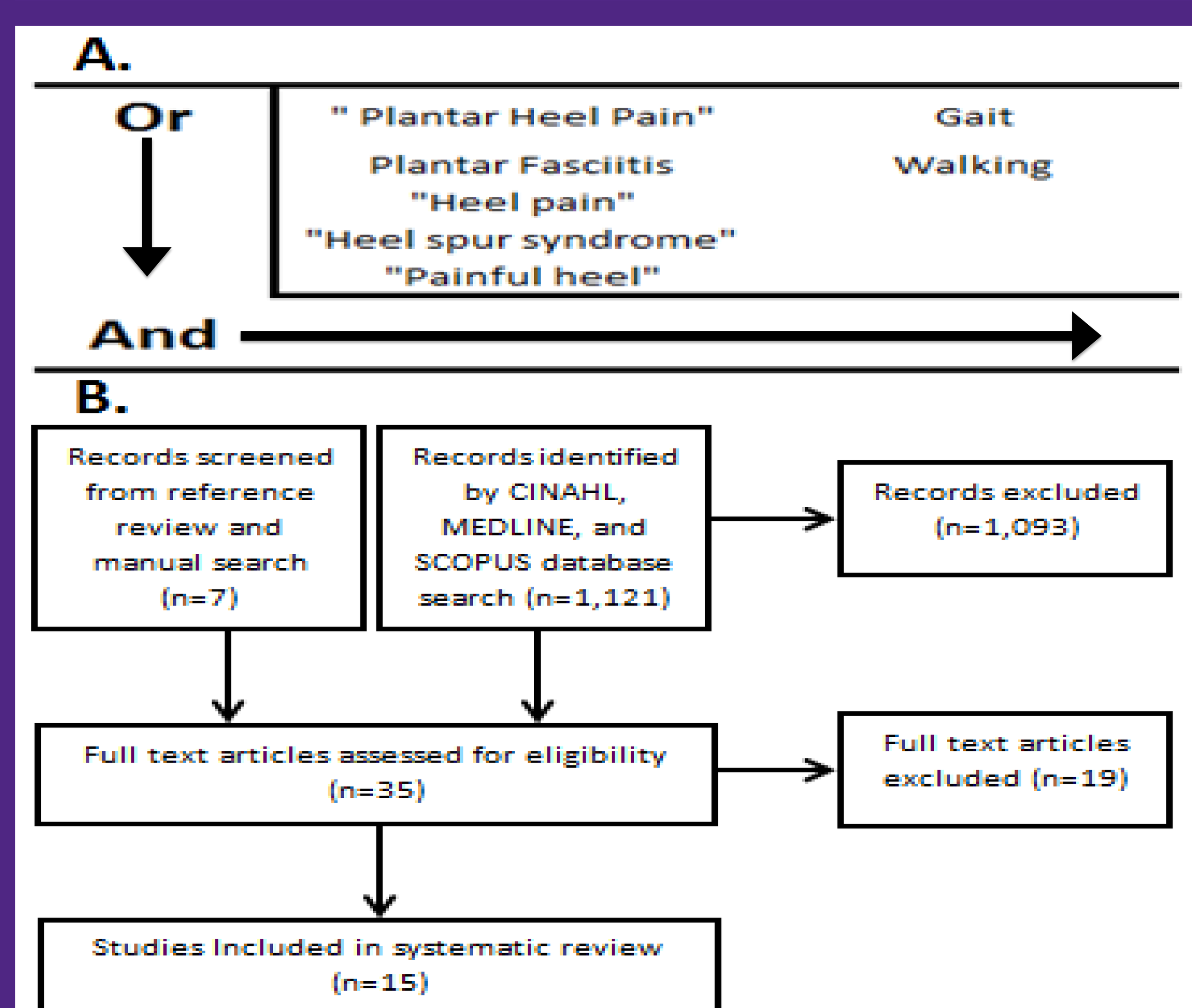

Fig 1. Summary of (A.) search criteria and (B.) search strategy

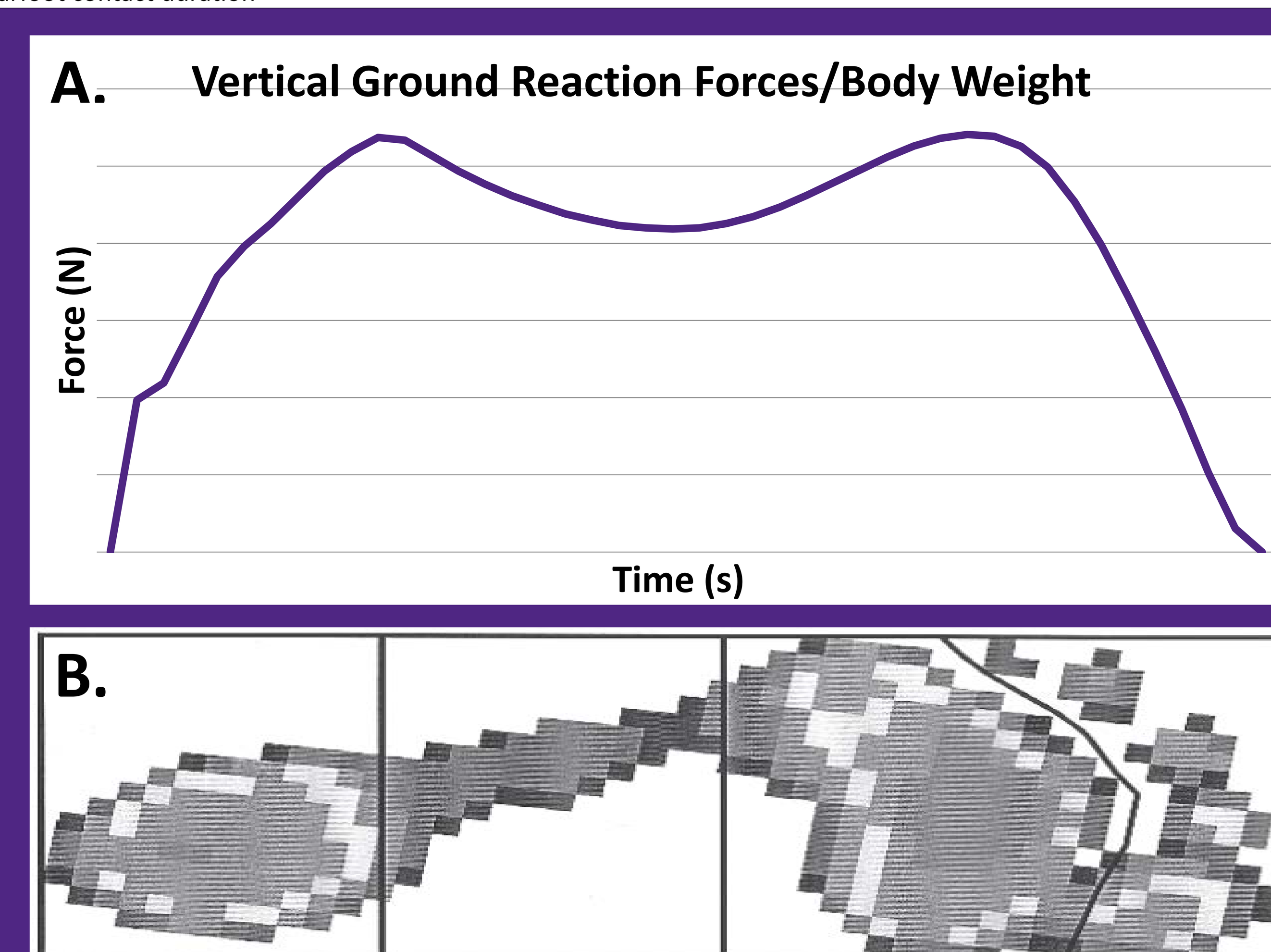

Fig 2. (A.) Sample force-time graph depicting vertical ground reaction forces during normal gait. (B.) Sample force footprint divided into rearfoot, midfoot, forefoot, and digits.

Results:

A total of 15 studies were selected for review. Six of the studies received a high methodological quality (>74%), and in total the studies received a mean score of 60.7%. A summary of the studies and their findings appear in **Table 1**. Strong evidence existed showing no difference in total stance phase duration, but there was limited evidence of decreased COP duration in the loading response phase, and decreased velocity during loading response phase. While there was conflicting evidence of altered regional impulses in PHP (**Fig 2**), limited evidence of reduced rearfoot impulse if the center of pressure (COP) method was used and very limited evidence of increased forefoot impulse in PHP. Examination of vertical ground reaction force variables found limited evidence for reduced peak force and a delayed time to vertical peak during terminal stance phase (**Fig 2A**). Based on 1 study, there was no difference in peak regional (hindfoot, midfoot, forefoot) vertical force, increased second metatarsal pressure, and increased maximum force in the digits (**Fig 2B**). Clinical observations of pronation and supination were reported, but the only quantified measure of pronation/supination including arch deformation measures included limited evidence of increased plantar flexion at initial contact and overall mobility of the medial forefoot in PHP.

Discussion:

Gait deviation is observed in individuals with PHP, but low study quality and measurement variation prevent a clear consensus on the most relevant gait deviations in PHP. While factors such as pronation, vertical ground reaction forces, and stance phase duration are common in the literature, the most effective methods to measure and therefore characterize these factors in pathological populations is not well established. Despite the limited or conflicting evidence of the studies reviewed, there does appear to be reduced and delayed loading of the rearfoot during initial stance phase and reduced and prolonged loading during terminal stance. Clinicians may focus on the initial and terminal stance phases to identify and manage gait dysfunction in PHP, but further study is needed. Studies with larger sample sizes or including direct comparison of different measurement techniques used to assess the same gait characteristic will help to increase confidence in relevant gait deviations in individuals with PHP. With further investigation, gait measures can be standardized and translated into feasible clinical practices to improve management of patients with PHP.

References/Acknowledgments:

See Attached