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# Predicting the outcome of plantar heel pain in adults: a systematic review of prognostic factors

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## Abstract

**Background** Plantar Heel Pain (PHP) is a common disorder with many treatment pathways and is not self-limiting, hence prognostic information concerning recovery or recalcitrance is needed to guide practice. In this systematic review, we investigate which prognostic factors are associated with favourable or unfavourable PHP outcomes.

**Methods** MEDLINE, Web of Science, EMBASE, Scopus and PubMed electronic bibliographic databases were searched for studies evaluating baseline patient characteristics associated with outcomes in prospective longitudinal cohorts or after specific interventions. Cohort, clinical prediction rule derivation and single arms of randomised controlled trials were included. Risk of bias was evaluated with method-specific tools and evidence certainty with GRADE.

**Results** The review included five studies which evaluated 98 variables in 811 participants. Prognostic factors could be categorised as demographics, pain, physical and activity-related. Three factors including sex and bilateral symptoms (HR: 0.49[0.30–0.80], 0.33[0.15–0.72], respectively) were associated with a poor outcome in a single cohort study. The remaining four studies reported twenty factors associated with a favourable outcome following shockwave therapy, anti-pronation taping and orthoses. Heel spur (AUC = 0.88[0.82–0.93]), ankle plantar-flexor strength (Likelihood ratio (LR): 2.17[1.20–3.95]) and response to taping (LR = 2.17[1.19–3.90]) were the strongest factors predicting medium-term improvement. Overall, the study quality was low. A gap map analysis revealed an absence of research that included psychosocial factors.

**Conclusions** A limited number of biomedical factors predict favourable or unfavourable PHP outcomes. High quality, adequately powered, prospective studies are required to better understand PHP recovery and should evaluate the prognostic value of a wide range of variables, including psychosocial factors.

**Keywords** Prognosis, Outcome predictors, Plantar heel pain

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## Background

Plantar heel pain (PHP) is one of the most troublesome and common foot conditions, with an estimated prevalence between 4 and 10% in the general population [1–4]. PHP is characterised by pain in the inferior-medial aspect of the rear-foot that is typically worse upon weight-bearing activities such as walking or standing or on weight bearing after periods of rest, and palpation of the medial tubercle of the calcaneus [4]. Consequently, PHP can have a negative impact on health-related quality of life, including limiting activities of daily living and contributing to social isolation [5].

Multiple treatment options are available for PHP. A recent comprehensive systematic review recommended stretching, taping and patient education in first-line management, with interventions such as shock wave therapy, foot orthoses and injections for those who fail to improve [6]. However, PHP can still remain resistant to treatment, and although some studies have reported high levels of spontaneous recovery within one year [7, 8], there is evidence of up to 50% recalcitrance at 10 years [9]. Multiple treatment options with unsatisfactory results may arise from the lack of tailoring management strategies due to limited understanding of the biopsychosocial factors that affect PHP prognosis. Prognostic factors are variables at baseline which are associated with a subsequent outcome of pain, function and disability, and can be evaluated with specific research designs such as prospective cohort studies, analysis of single arms in randomised controlled trials (RCTs) and clinical prediction rule derivation studies. To inform clinical care and delivery and to better understand the likely course of an individual's condition, there is a need to identify and evaluate prognostic factors.

In other musculoskeletal conditions, such as patellofemoral pain, prognostic factors such as a disease duration of longer than 2 months, lower scores on an anterior knee pain scale and higher activity-related pain may predict those who have a poor 12-month prognosis [10]. A recent systematic review of prognostic factors in tendinopathy showed that limited evidence exists linking psychological variables and tendinopathy, and suggested that using validated screening tools for the presence of psychological variables should be a part of their holistic management [11]. While there are multiple systematic reviews and clinical practice guidelines that have evaluated the effectiveness of interventions for PHP there is no review of prognostic factors for PHP.

We aimed to inform clinical care for PHP by 1) determining which baseline patient characteristics are associated with outcomes in observational cohorts or after specific interventions, and 2) analysing the quality of the available research and the gaps within it (i.e. identify biomedical, physical and psychosocial variables that have

yet to be investigated). This second aim will influence best practise and help researchers who want to work in the field of PHP prognosis and direct their efforts more effectively by guiding future work to improve our understanding of outcomes for this troublesome, common and recalcitrant condition.

## Methods

The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed [12], and a published guideline for design and reporting of systematic reviews of prognostic factor [13]. The review protocol was registered on PROSPERO (CRD42020205005).

### Search strategy

Electronic databases (Ovid MEDLINE, Scopus, Embase, Pubmed and Web of Science) were searched from inception to June 2020. Key search terms used in the selection process relating to PHP were [plantar heel pain OR plantar fasci\* OR heel pain syndrome], which were adapted from previous studies with similar search strategies [6, 14]. Keywords of [success\*, factor\*, predict\*, charact\*, prognos\*] were used in combination with the keywords related to PHP, in order to capture primary prognostic research [15]. The complete search strategy is reported in the electronic supplementary material.

### Eligibility criteria

Studies investigating baseline characteristics with follow-up of patient-reported outcomes relating to indicators of recovery (e.g. pain and/or function) after at least one week were included. Studies were also required to clearly define recovery and provide an effect size for the prognostic estimate. Prospective cohort studies, single arm clinical trials reporting prognostic factors and studies [16] developing clinical prediction rules were included. The inclusion and exclusion criteria are presented in Table 1.

No publication date limits, or language restrictions were set RCTs that were not considered single arm prognostic research studies were excluded, as were retrospective studies due to the low level of evidence [16].

### Types of participants

Studies which investigated adult participants over 18 years of age with a clinical diagnosis of PHP were included. To be consistent with previously published criteria [17], we included participants with a diagnosis of PHP of greater than one month duration that is worse on weight bearing, or on weight bearing after periods of rest, and palpation of the medial tubercle of the calcaneus. Studies including participants without

**Table 1** Inclusion criteria for eligible studies

Inclusion criteria
Design:
• Prospective cohort study; single arm clinical trials or clinical prediction rule derivation study;
Participants
• Inferior heel pain, that is pronounced with weight bearing or upon weight bearing after periods of rest and pain in palpation of the medial tubercle of the calcaneus for more than 1 month
Main outcome and outcome measures
• Recovery of plantar heel pain by measuring pain and function (i.e. VAS, FFI, GROC, PSFS)
Measures of effect size:
• At least one possible effect size measure e.g. odds ratios, risk ratios, hazard ratios, positive likelihood ratio, and area under curve
Language:
• No restrictions, with translators readily available

Key: VAS Visual analog scale, FFI Foot function index, GROC Global rating outcome scale, PSFS Patient specific functional scale

a clear diagnosis of PHP, and/or describing pain in other body areas, including other foot pathologies were excluded (Table 1).

### Review process

Identified studies were imported into Endnote X6 (Thomson Reuters, Carlsbad, California, USA) where duplicates were removed, before uploading to Rayyan QCRI (Computing Research institute, QATAR) for title and abstract screening. Two reviewers independently assessed study titles and abstracts, screened full-texts, verified eligible papers, and completed the quality assessments. A third reviewer (HG and XL) was available for difficult decisions and to resolve discrepancies.

### Data extraction and data synthesis

Data were extracted from studies on September 2020 according to the CHECKlist for critical Appraisal and data extraction for systematic Reviews of prediction Modeling Studies (CHARMS) [18]. As studies had different durations, follow-up lengths were categorized as short term (range 0–12 weeks), intermediate (13–26 weeks) and long term (1 year,  $\geq 52$  weeks), and long term ( $\geq 52$  weeks) [6].

All results, including non-significant prognostic factors, were extracted from each study. Any prognostic factor investigated by multiple studies for different time periods, effect measures and scores (e.g., Hazard ratio (HR), + Likelihood ratio (LR+), Area Under Curve (AUC) and *P* value) and level of evidence, were tabulated and

presented graphically as a gap map in table 4. It was also included psychological and social contextual (cultural) factors potentially relevant when analysing a patient's presenting problems [19].

According to recommendations by Riley et. al (2019), meta-analyses were not performed due to the diverse range of effect sizes, study methodologies, and adjustments for covariates.

### Quality assessment

Study quality was evaluated using the Quality Assessment of Diagnostic Clinical Prediction Rules (QUADCPR) which consists of 23 items divided into four sections, with each item scoring yes (score=2), no (score=0) or unclear (score=1), which makes 54 of total score. The first section includes a checklist of items related to the sample and participants; the second section focuses on the reporting of outcome measures; the third section relates to the quality of tests and measures; and the final section focuses on the quality of reporting related to statistics [20].

The Epidemiological Appraisal Instrument (EAI) includes 43 items which are scored as yes (score=2), partial (score=1), no (score=0) or unable to determine (score=0). Questions 10, 22, 23, 24 were removed as they are not applicable to intervention studies. The EAI has proven to be a valid and reliable evaluation method that can be used in different applications, such as systematic evaluations and meta-analyses [21].

### Risk of bias assessment

The Quality In Prognosis Studies (QUIPS II) was used to tool has been found to be useful and reliable for systematic reviewers, study authors, and readers to guide comprehensive assessment of bias in studies of prognostic factors [22]. It includes 24 items across 6 domains including study participation, study attrition, prognostic factor measurement, outcome measurement, study confounding, statistical analysis and reporting. The overall assessment of the six risk of bias domains judgments were scored as yes, partially, unsure or no [23]. Each of the six domains were rated independently by two reviewers (HG and XL).

### Evaluation of the quality of evidence using GRADE

Evidence levels were established based on the modified Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework [24]. The phase of investigation was considered as a starting point. As all included articles were categorised as phase 1 explanatory

studies, they were judged as moderate level of evidence at the beginning according to recommendations [24]. Afterwards, the evidence level was downgraded based on the following descriptions:

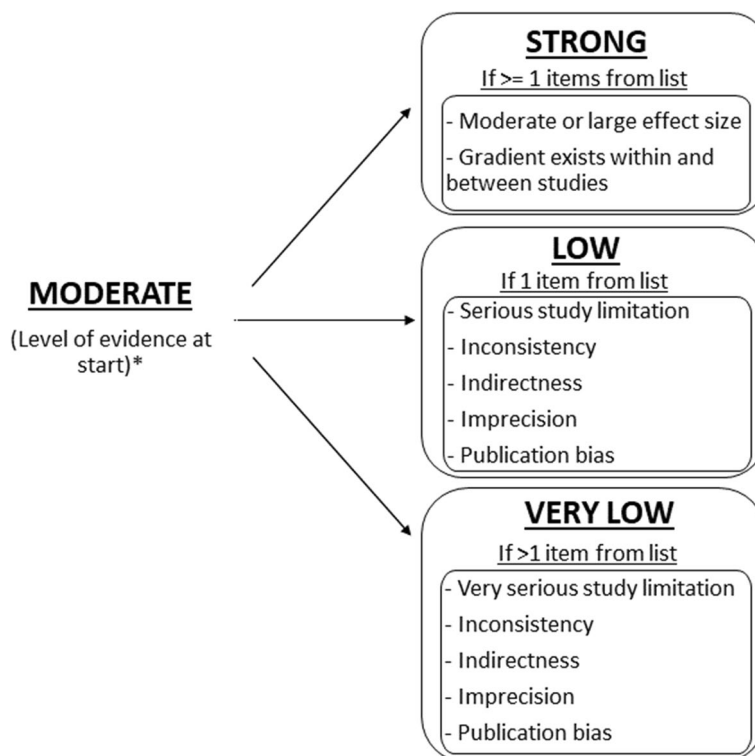
- 1 Study limitations: a) serious limitations when most evidence is from studies with moderate or unclear risk of bias for most bias domains; b) very serious limitations when most evidence is from studies with high risk of bias according to QUIPS II.
- 2 Inconsistency: variations in effect estimates across studies or providing different results for the same variables.
- 3 Imprecision (within-study imprecision): a) sample size justification is not provided and there are less than 10 outcome events for each prognostic variable b) points of effect on either side of the line of no effect, and confidence intervals showing minimal overlap.
- 4 Publication bias: all studies are downgraded in this item due to their study phase [24, 25]. Evidence level were upgraded based on the following descriptions:
  - a Moderate or large effect: a moderate or large similar effect is reported in the study.

Figure 1 presents a guide for adjustments to the quality of evidence using criteria outlined by Huguet et al., (2013) [24]. A range of effect size measures were determined based on previous literature, including Hazard Ratios (HRs), Likelihood Ratios (LRs) and Area Under the Curve (AUC) Small, medium, and large Hazard Ratios (HRs) for a standard deviation increase in the predictor were classified as 1.14, 1.47, and 1.9, respectively [26]. Likelihood ratios (LRs) LR + 5–10 represents moderate probability; LR + 2–5 generate small but important probability; LR + 1–2 generate small but rarely important probability [27]. Regarding the AUC, a ROC = 0.5, suggests no discrimination; 0.7 < ROC < 0.8 is considered acceptable; 0.8 < ROC < 0.9 is considered excellent and if the ROC > 0.9 it is considered outstanding [28].

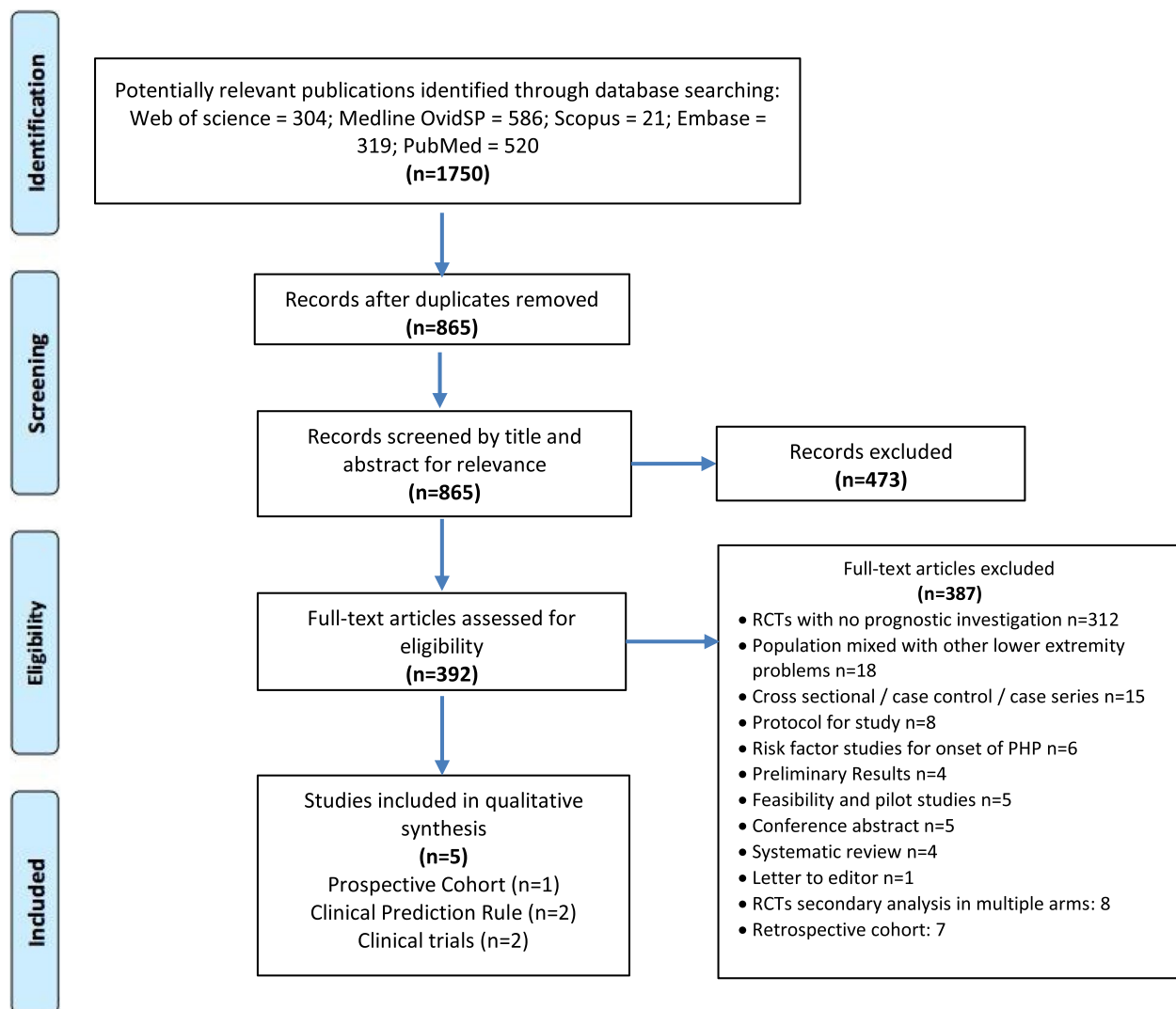
**Results**

**Search results and critical appraisal of methods**

After search strategy, we included 5 studies (Fig. 2) investigating 811 participants with PHP in total (range = 74 to 278). The results of the quality assessment, a summary of the included 225 studies and outcome predictors are presented in Table 2, Table 3, and Table 4, respectively.



**Fig. 1** Guide for adjustments to the quality of evidence for prognosis; This diagram is adapted from Huguet et. al (2013). \* In this review, moderate level of evidence is the starting point for outcome prediction research or explanatory research aimed to identify associations between potential prognostic factors and the outcome (Huguet et. al., 2013)



**Fig. 2** PRISMA flow diagram; Key: n = number, RCTs = Randomized controlled trials

### Quality assessment

The quality of four studies [29–32] were evaluated using the QUADCPR [20] and one single cohort study by Hansen et al. (2018) [9] was evaluated using the EAI tool [21]. The reporting of the study aims, setting and description of sample characteristics were found to be of good quality. However, there were a lack of information regarding reliability and validity of the main outcome measures used, first order interaction in the statistical analyses, validity and reliability of the model, and covariate/confounders analyses for the factors according to EAI. The items which led to discrepancy between two reviewers were “outcome measure reliability, validity and sensitivity to change”, “first order interactions were assessed and reported” and “irrelevant predictors removed prior to multivariate modelling” in

the QUADCPR assessment tool. Details of the quality assessments are presented in Table 2.

### Risk of bias assessment

There were 30 domains in total across the five studies, with 7 domains (23%) classed as low, 13 (43%) classed as moderate, and 10 (34%) classed as high RoB (Fig. 3) [29, 30]. There were no missing data for prognostic factor measurements in four studies. However, Hansen et al. did not report in the data analysis section if the study had any missing/incomplete data due to drop-out [9]. For outcome measurements, three studies [9, 31, 32] were classified as having moderate RoB because specific clinical or imaging outcome measurements were either inadequately described or not stated [9, 31, 32]. Regarding the study confounding domain, all studies



**Table 2** Quality assessment of studies using QUADCPR and EAI

QUADCPR	Wu, 2019	Wu, 2018	Yin, 2019	Yin, 2017	Hansen 2018	EAI for Hansen 2018 only
Setting and location	2	2	2	2	Yes	Study aim
Inclusion / exclusion	2	2	2	2	Yes	Exposure description
Sample characteristics	2	2	2	2	Yes	Main outcome measure
Sampling	2	2	2	2	Yes	Study Design
Outcome measures	2	2	2	2	Yes	Source of population
Outcome measure parameters	2	2	1	1	Yes	Eligibility Criteria
Blinded outcome measures	0	0	2	2	Yes	Participation rates
Outcome measure definition	2	2	2	2	Yes	Participant characteristics
Predictors test	2	2	2	2	Yes	Participants characteristics for dropout
Predictor test performed	2	2	2	2	No	Intrinsic patient characteristics
Predictor test and measures	2	2	2	2	No	Extrinsic factors described
Predictor tests/measures acceptability	2	2	2	2	Yes	Statistical methods
Examining clinicians blinded	0	0	2	2	Yes	Main findings of study
Treating clinicians blinded	0	0	2	2	Yes	Reported variability of data
Reliable predictors tests	2	2	2	2	Yes	Statistical parameters
Appropriate time interval	2	2	2	2	No	Sample Size calculations
Equivocal or indeterminable results	2	2	2	2	Yes	Comparability of case/control
Adequate sample powering	2	2	2	2	Yes	Participation rates case/control
First order interactions were assessed	0	0	0	0	Yes	All groups are recruited the same period
Statistical significance/fit of the model	0	0	2	2	Yes	Subject losses taken into account
Confidence intervals of the analyses	2	2	2	2	UTD	Exposure variables reliable
Irrelevant predictors removed	2	2	2	2	UTD	exposure variables valid
Results were reported using %95 ci	2	2	2	2	Yes	Methods similar for each group
Intervention procedures are explanation	2	2	2	2	Yes	Exposure prior to outcome
Intervention(s) method suitability	2	2	2	2	No	Blinded observers
Comparator procedures details	2	2	2	2	Yes	Subjects blinded
Comparator intervention method suitability	2	2	2	2	UTD	Main outcomes measures reliable
					UTD	Main outcome measures valid
					Yes	Assessment method for all groups
					Yes	Observations taken at same time point
					No	Covariates/confounders analyses intrinsic
					No	Covariates/confounders analyses for extrinsic
					UTD	Sufficient follow-up time
					No	Analyses different lengths of follow-up
					No	Levels of exposure outcome
					Yes	Reported data for subgroups of subjects
					Yes	Generalizability to study populations
					Yes	Generalizability to other populations
<b>Total score</b>	<b>44/54</b>	<b>44/54</b>	<b>51/54</b>	<b>51/54</b>	<b>57/90</b>	
<b>Total Score (%)</b>	<b>81.4</b>	<b>81.4</b>	<b>94.4</b>	<b>94.4</b>	<b>63.1</b>	

Key = UTD Unable to Detect, QUADCPR Modified Quality Assessment of Diagnostic Clinical Prediction Rule, EAI The Epidemiological Appraisal Instrument; 2 = yes; 1 = unclear; 0 = no. Inter-rater agreement between the quality assessors was 82% across all 5 papers

Inter-rater agreement between the quality assessors was 92% across all 13 papers

\* Modified in accordance with the TRIPOD statement<sup>23</sup> recommendation for a minimum of 10 participants in the limiting sample size (ie, those who experienced the least frequent outcome) for each potential predictor variable included in the analysis

were scored as having a high RoB because definitions of confounding factors or adjustments were either unclear or not reported. Finally, all studies had moderate RoB on the statistical analysis domain as data were presented with insufficient detail, with the justification for statistical modelling outlined but no evidence of selective reporting.

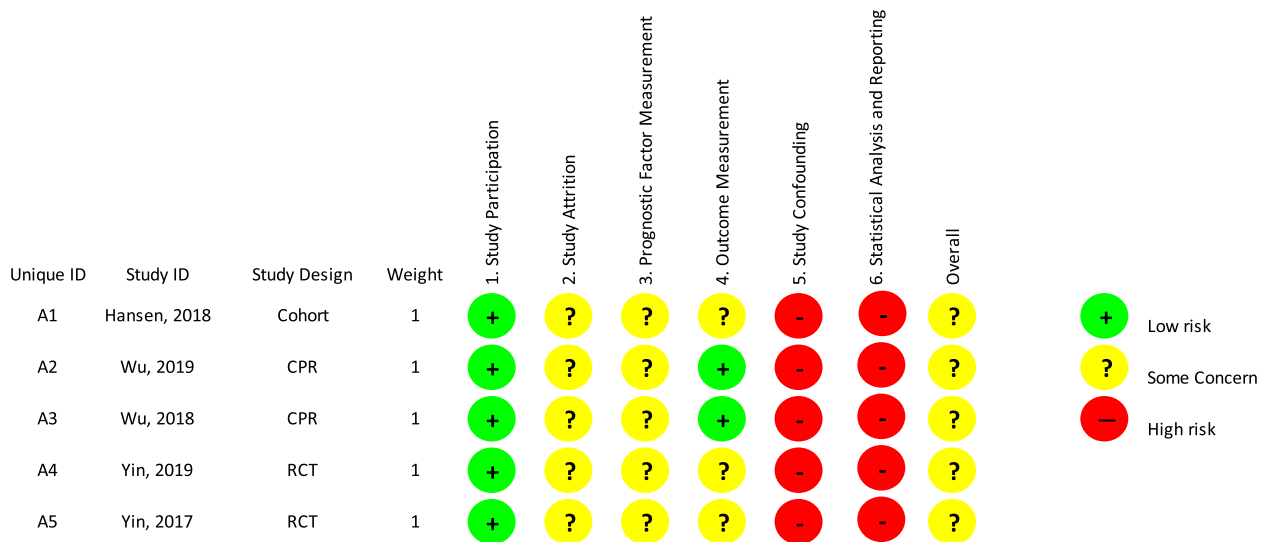
**Summary of findings**

Studies in this review reported two directions (favourable vs unfavourable) of a statistically significant relationship. All estimate sizes of the relationships were presented as reported in the source multivariate analyses. Included below are a summary of findings presented under two headings including (i) participant characteristics

**Table 3** Characteristics of 5 included studies

Study	Participants		Treatment		Outcomes to be predicted		Analysis		
	Study and design	Ss and events	Prescribed Treatments	Permitted Treatment	Positive Outcome criteria	Follow-up length		Modelling method	
Hansen, 2018 Cohort study	174	Age: 26—88 years, BMI: 17.8—43.3 kg/m <sup>2</sup> Sex: 91 (52%); 83 (48%)	93% US-guided injections	Various physiotherapy modalities	Scored > 0 on the NRS in either rest, during walking, during running, or on pressure	5 to 15 years	Multiple Cox regression analysis	9	1. Gender 2. Bilateral heel pain
	Wu, 2019, Clinical Prediction Rule	75 49	Age: 48.4 ± 14.5 years, BMI: 23.8 ± 3.7 kg/m <sup>2</sup> Sex: 57 (77%); 17 (23%)	Customized foot orthosis	Not allowed	(1) Reducing the pain intensity > 2 points or 50%, (2) Decreasing the FFI score > 7 points or PSFS score > 50% (3) Improving GROC scale of +4	6 months	Multiple logistic regression	63
Wu, 2018, Clinical Prediction Rule	74 28	Age: 48.4 ± 14.5 years, BMI: 23.8 ± 3.7 kg/m <sup>2</sup> Sex: 58 (77%); 17 (23%)	Anti-pronation taping	Not Reported	(1) Reducing the pain intensity > 2 points or 50%, (2) Decreasing the FFI > 7 points or PSFS score > 50% (3) Improving GROC scale of +4	1 week	Multiple logistic regression	79	1. FFI score less than 33.3, 2. Unbalanced hip adduction angle, 3. Unbalanced ankle PF and hip abductors, 4. Unbalanced on ankle invertors, 5. > 2 painful sites in lower extremity regions
	Yin, 2017, Clinical Trial	278 186	Age: 55 ± 13.3 years, BMI: 107(38.5%) < 26 kg/m <sup>2</sup> , 147 (52.9%) 26–30 kg/m <sup>2</sup> 24 (8.6%) > 30 kg/m <sup>2</sup> Sex: 136(49%); 142(51%)	ESWT	Not Reported	Reducing the pain intensity > 2 points or 50%,	3 months	Multiple stepwise logistic regression	10
Yin, 2019, Clinical Trial	210 140	Age: 54.1 ± 13.6 years, BMI: 76(36.2%) < 26 kg/m <sup>2</sup> , 112 (53.3%) 26–30 kg/m <sup>2</sup> 22 (10.5%) > 30 kg/m <sup>2</sup> , Sex: 98 (47%); 112(53%)	ESWT	Not Reported	Reducing the pain intensity > 2 points or 60%	6 months	Artificial neural networks	10	1. VAS, 2. Heel spurs 3. Duration of symptom

**Key:** Ss total sample size, f female, m male, n number, NRS Numerical rating scale, BMI Body Mass Index, kg kilogram, m<sup>2</sup> meter square, ESWT Extracorporeal shockwave therapy, VAS Visual Analog Scale, FFI Foot Function Index, GROC Global Rating of Change, PSFS Patient Specific functional scale, PF Plantar Flexion, IR Internal Rotation, ER External Rotation



**Fig. 3** Risk of Bias assessment using QUIPS II; Key: CPR=Clinical prediction rule, RCT=randomized controlled trial

associated with an outcome in a cohort study and (ii) participant characteristics associated with an outcome after a specific treatment.

**Participant characteristics associated with an outcome in a cohort study**

One study investigated the association between participants’ baseline characteristics and a poor PHP outcome [9]. Ninety-three percent of participants in this cohort study were reported to receive various treatment strategies such as injections, insoles, exercises and ESWT. Nine patient-reported and anatomical characteristics were investigated. Multiple Cox regression analyses revealed only two patient characteristics (sex and having bilateral heel pain) were associated with a poor outcome (Table 3).

**Demographics**

There was low evidence of a small effect that a patient being female was a predictor of an unfavourable outcome in the long term (HR: 0.49 [0.30–0.80]) (i.e. “for every 100 men cured per year, only 49 women were cured”) [9]. BMI and smoking were not shown to be significant prognostic factors at this time-point (Table 4).

**Pain-related factors**

There was low evidence of a small effect that having bilateral heel pain was a predictor of an unfavourable outcome in the long term of PHP when controlling for sex, age BMI, smoking, physical work, time to ultrasound, fascia thickness and heel spur. The hazard ratio of 0.33 [0.15–0.72] indicates that the chance of being asymptomatic for those with bilateral pain was 33% relative to

people with unilateral pain [9]. It should be acknowledged that being asymptomatic for those with bilateral pain referred to pain relief on the most affected side.

**Participant characteristics associated with an outcome after a specific treatment**

Three different specific treatments, foot orthoses [30], biomechanical anti-pronation taping [29] and extracorporeal shock wave therapy (ESWT) were investigated in four studies [29–32]. Two studies investigated predictive factors for a minimum clinically successful therapy after extracorporeal shock wave therapy at 3 and 6 months [31, 32]. Fourteen participant characteristics, including pain, physical and function-related factors, were reported to be associated with a successful outcome after a specific treatment.

**Pain-related factors**

There is very low evidence of small effect that the number of painful sites in the lower back and the lower extremity region were a predictor of success for anti-pronation taping intervention in the short term [29]. Authors included the number of painful sites as a potential independent variable in their prognostic models recognising the potential the biomechanical interaction between foot pronation and lower extremity pathologies. Similarly, there is moderate evidence of a large effect that decreased pain by over 1.5 points (on a 10 point scale), as a response to anti-pronation taping, was a predictor of foot orthoses success in the medium term when controlling for range of ankle plantar flexion, ankle plantar-flexor strength, and range of hip internal–external rotation (+LR: 2.17



**Table 4** Investigated prognostic factors across long-, medium- and short-term follow-up duration, with effect measure, size, direction and GRADE which is coded using colour system in the last column. Red, orange, yellow and green show very low, low, moderate, and high-level of evidence, respectively. Grey is no investigation/evidence in relevant

Prognostic factors investigated	Total n (total)	Follow-up duration	Studies	Effect measure	Multivariate Effect size (95% CI)	GRADE				Publication bias	Summary
						Consistency	Mod./Range	Precision	Imprecision		
<b>DEMOGRAPHICS</b>											
Sex (findings relate to being female)	811 (447)	L	M	H18	HR 0.49 (0.30-0.80)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	✓	✓	✓	✓	↓
				Y17	NR	NR	✓	✓	✓	✓	↓
Age (findings relate to being over 40)	811 (NR)	L	M	H18	HR 1.93 (0.99-3.73)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	✓	✓	✓	✓	↓
				Y17	NR	NR	✓	✓	✓	✓	↓
Higher BMI	811 (NR)	L	M	H18	HR 0.65 (0.40-1.06)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	✓	✓	✓	✓	↓
				Y17	NR	NR	✓	✓	✓	✓	↓
Smoking	174 (39)	L	M	H18	HR 0.88 (0.53-1.52)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	✓	✓	✓	✓	↓
				Y17	NR	NR	✓	✓	✓	✓	↓
Right dominant Leg	149 (135)	L	M	W18	NR	NR	NA	✓	✓	✓	↓
				W19	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
<b>PAIN</b>											
Bilateral heel pain	736 (174)	L	M	H18	HR 0.33 (0.15-0.72)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	✓	✓	✓	✓	↓
Shorter duration of symptoms / pain history	637 (NR)	L	M	W19	NR	NR	✓	✓	✓	✓	↑
				Y17	AUC 0.52 (0.43-0.60)	✓	✓	✓	✓	↓	
				W18	NR	1.00 (0.60-1.60)	✓	✓	✓	✓	↓
First-step pain	149 (NR)	L	M	W19	NR	NR	NA	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Lower average Pain intensity	637 (NR)	L	M	W19	+LR 1.34 (0.70-2.17)	✓	✓	✓	✓	✓	↑
				Y17	AUC 0.73 (0.65-0.80)	✓	✓	✓	✓	↓	
				W18	NR	NR	✓	✓	✓	✓	↓
Response to taping (decreased pain)	75 (NR)	L	M	W19	+LR 2.17 (1.19-3.90)	NA	✓	✓	✓	✓	↑
				W18	NR	NR	✓	✓	✓	✓	↓
				Y17	AUC 0.75 (0.69-0.80)	✓	✓	✓	✓	↓	
Lower number of painful sites in LE	74 (NR)	L	M	W18	+LR 1.60 (0.90-2.70)	NA	✓	✓	✓	✓	↑
				W19	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Onset, (gradual)	149 (97)	L	M	W19	NR	NR	NA	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
<b>PROMs</b>											
FFI score (≤33)	149 (NR)	L	M	W19	+LR 1.50 (1.00-2.30)	NA	✓	✓	✓	✓	↑
				W18	+LR 1.81 (1.50-3.18)	NA	✓	✓	✓	✓	↑
				Y17	NR	NR	NA	✓	✓	✓	↓
Higher RM	488 (NR)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Higher PSFS	149 (NR)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
<b>PHYSICAL</b>											
Thicker Fascial thickness	174 (NR)	L	M	H18	HR 1.20 (0.72-1.98)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Ankle PF ROM (≥54 degree)	75 (NR)	L	M	W19	+LR 1.38 (0.80-2.37)	NA	✓	✓	✓	✓	↑
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Higher Ankle PF strength (ct. asymptomatic side)	149 (NR)	L	M	W19	+LR 2.17 (1.20-3.95)	NA	✓	✓	✓	✓	↑
				W18	+LR 1.50 (1.00-2.10)	NA	✓	✓	✓	✓	↑
				Y17	NR	NR	NA	✓	✓	✓	↓
Higher Ankle inventor strength (ct. asymptomatic side)	149 (NR)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	+LR 1.20 (0.90-1.80)	NA	✓	✓	✓	✓	↑
				Y17	NR	NR	NA	✓	✓	✓	↓
Hip internal rotation (≥39 degree)	149 (NR)	L	M	W19	+LR 1.79 (0.96-3.30)	NA	✓	✓	✓	✓	↑
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Hip external rotation (≥45 degree)	149 (NR)	L	M	W19	+LR 1.53 (0.98-2.40)	NA	✓	✓	✓	✓	↑
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Higher hip adduction angle (ct. asymptomatic side)	149 (NR)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	+LR 1.40 (1.10-1.90)	NA	✓	✓	✓	✓	↑
				Y17	NR	NR	NA	✓	✓	✓	↓
Higher hip abductors strength (ct. asymptomatic side)	149 (NR)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	+LR 1.30 (0.90-2.70)	NA	✓	✓	✓	✓	↑
				Y17	NR	NR	NA	✓	✓	✓	↓
Not having heel spur	662 (304)	L	M	H18	HR 0.88 (0.51-1.52)	NA	✓	✓	✓	✓	↓
				W19	AUC 0.88 (0.82-0.93)	NA	✓	✓	✓	✓	↓
				Y17	AUC 0.85 (0.81-0.89)	NA	✓	✓	✓	✓	↓
Not having oedema	488 (108)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	AUC 0.65 (0.60-0.71)	NA	✓	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Other physical variables	488 (NR)	L	M	W19	No effect*	NA	✓	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
<b>ACTIVITY</b>											
Higher Physical work	323 (NR)	L	M	H18	HR 0.68 (0.46-1.20)	NA	✓	✓	✓	✓	↓
				W19	NR	NR	NA	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
Longer Standing Hours	149 (NR)	L	M	W19	NR	NR	NA	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
Having Exercise behaviour	74 (39)	L	M	W19	NR	NR	NA	✓	✓	✓	↓
				W18	NR	NR	NA	✓	✓	✓	↓
				Y17	NR	NR	NA	✓	✓	✓	↓
<b>PSYCHOLOGY</b>											
L	M	S									
<b>SOCIAL</b>											
L	M	S									

**Table 4** (continued)

KEY = -: not investigated; Results in BOLD type reveal a statistically significant results ( $p < 0.05$ ). Case refers to number of variables which have been indicated to be a predictive factors

NA not applicable, HR Hazard Ratio, RR Relative Risk, AUC Area under the curve, +LR positive likelihood ratio, NR Not Reported, L Long Term, M Medium term, S Short-term outcomes

\* No reported effect, studies provided only p value. Ct: Compare to. Articles: H18: Hansen et al, 2018 (Cohort study); W18: Wu et al, 2018 (RCTs); W19: Wu et al, 2019 (RCTs); Y17: Yin et al, 2017 (RCTs); Y19: Yin et al, 2019 (RCTs). Red, orange, yellow and green show very low, low, moderate, and high-level of evidence, respectively. Grey is no investigation/evidence in the relevant period. Arrow key: Up arrow: the value of the factor has a positive effect on prognosis; down arrow: the value of the factor has a negative effect on prognosis; Horizontal arrow: Prognosis probability is not affected by a change in the value. Publication bias and study limitation of GRADE's domains are not shown in the table due to similar results across all studies (i.e. negative). Regarding the precision of studies, studies scored as unclear—not having SD or CI are considered as imprecise. For GRADE factors: ✓, no serious limitations; ✗, serious limitations (or not present for moderate/large effect size, dose effect); unclear, unable to rate item based on available information

[1.19–3.90]) [30] (Table 4). The indicator of foot orthoses success and study characteristics of the other four included publications were presented in Table 3.

There was very low evidence of small effect that a shorter history of symptoms and average pain intensity predicted a favourable outcome following an ESWT intervention in the medium term when controlling for the presence of a heel spur (AUC: 0.52 [0.43–0.6], 0.73 [0.65–0.80], respectively) [32]. Average pain intensity was also a predictor of a favourable outcome in the short term, for the same intervention, when controlling for the presence of oedema and a heel spur (AUC: 0.75 [0.69–0.08]) [31]. There were no associations found between PHP prognosis and either bilateral heel pain, first step pain or the onset of pain (P value > 0.05).

**Patient Reported Outcome Measures (PROMs)**

There was low evidence of a small effect that scoring lower than 33.3 on the FFI was a predictor of anti-pronation taping intervention success in the short term (+LR: 1.81 [1.50–3.18]) [29]. Results revealed no significant evidence for the predictive effects of the PSFS and Roles and Maudsley score (RM) on the prognosis of PHP or a favourable outcome to an intervention (Table 4).

**Physical factors**

There was very low evidence of small effect that increased ankle plantar flexor ROM (> 54°), reduced hip internal ROM (< 39°) and increased hip external rotation (> 45°) were positive predictors of foot orthoses intervention success in the medium term (+LR: 1.38 [0.80–2.37], 1.79 [0.96–3.30], 1.53 [0.98–2.40], respectively) [30]. However, it is important to note that the LR values where the associated 95% confidence intervals contain 1 suggest that these the values were not precise enough to be statistically significant although they

were indicated as meaningful predictors in the source paper. In addition to this, there was low evidence of a small effect that higher or equal ankle plantar flexor strength compared to the asymptomatic side predicted a favourable outcome of foot orthoses in the medium term (+LR: 2.17 [1.20–3.95]) [30]. However, there was only low evidence of a small effect size that the plantar flexor strength variable was a positive predictor of the favourable outcome of anti-pronation taping in the short term (+LR: 1.50 [1.00–2.10]) [29]. There was low evidence of a small effect that greater hip adduction angle in the symptomatic side was a positive predictor of anti-pronation taping intervention success in the short term (+LR: 1.40 [1.10–1.90]) [29]. There was very low evidence of a small effect that lower ankle invertor, hip abductors and ankle plantar flexion (PF) strength in the symptomatic side were positive predictors of favourable outcome for the anti-pronation taping intervention in the short term (+LR: 1.20 [0.90–1.80], 1.30 [0.90–2.70], respectively) [29].

There was low evidence of a small effect that not having oedema was an indicator of a favourable outcome of ESWT intervention in the short term (AUC: 0.65 [0.60–0.71]) (Table 4) [31]. Finally, there was moderate evidence of a large effect that not having a heel spur predicted a favourable outcome of ESWT in the short to medium term when controlling for oedema and average pain intensity (AUC: 0.88 [0.82–0.93], 0.85 [0.81–0.89], respectively) [31, 32]. There were also other lower extremity variables (details are reported in the supplementary file) that were tested, however, none of them were found as statistically significant predictors of PHP prognosis ( $P$  values > 0.05).

### Activity

Results revealed that physical work was not associated with an outcome for ESWT, anti-pronation taping or an orthotic intervention in the short and medium term. Standing hours and exercise behaviour were not associated with the outcome for anti-pronation taping and foot orthoses in the short and medium term (Table 4).

### Discussion

This systematic review aimed to provide a comprehensive examination of patient characteristics associated with outcomes from 811 people with PHP. We found that people with PHP who are female and have bilateral heel pain are at risk of a poor outcome as revealed by a single prospective cohort study [9]. The immediate effects of taping, symptom duration and the number of painful sites are also prognostic indicators of recovery, as are a variety of ankle and hip kinematics such as increased ankle plantar flexion and hip rotation range. However,

it is important to note that those prognostic factors are for PHP in the context of specific interventions such as anti-pronation taping, orthosis and shockwave therapy and therefore not generalisable. There is a major need for high quality, detailed, adequately powered prospective studies of prognostic factors. These should cover a range of biopsychosocial domains for this common, problematic and recalcitrant condition.

The single cohort study by Hansen et al., (2018) [9] revealed that having bilateral heel pain and being female were predictive of a negative prognosis. Several studies report that sex differences related to pain and recovery exist [33, 34]. However, the specific underlying mechanisms contributing to this disparity are unknown. Therefore, further research exploring the effect of sex on recovery of PHP is needed and earlier interventions might need to be considered to prevent chronicity for female patients.

Hansen et al. (2018) [9] reported a poorer outcome for patients with bilateral heel pain. People with PHP usually develop PHP in a single foot initially [35–37] with symptoms becoming present in the contralateral foot as severity increases, possibly due to altered gait or because intrinsic and extrinsic risk factors apply to both limbs. Further, those with bilateral symptoms are likely to be more severely affected [38], which is important to consider for planning management.

In a clinical prediction rules study that reported the short-term use (2–3 days) of anti-pronation taping, it was revealed that the number of painful sites in the lower back and lower extremity regions were associated with a favourable outcome for anti-pronation taping. Therefore, clinicians might consider assessing the total number of painful sites -particularly the low limb and low back- to understand the severity of plantar heel pain.

Wu et al. (2018) who reported clinical prediction rules for anti-pronation taping revealed that various physical factors were associated with a favourable outcome [29]. These included having ankle plantar flexor and hip abduction strength equal or greater than the contralateral side, weaker ankle inverters and a greater range of hip adduction. It is not possible to determine that these factors are causative from this paper. However, it could be postulated that subjects with better strength and flexibility at the hip, with a bias to weak ankle inversion, have a better response to anti-pronation taping.

Prognostic research for PHP would be improved by the development of a PROM that is better suited to the particular presentation of PHP. The FFI score was identified as a PROM that predicted success of anti-pronation taping by measuring functional severity at baseline (i.e. There was low evidence of a small effect that scoring lower than 33.3 on the FFI was a predictor of anti-pronation taping

intervention success in the short term) [29]. There are also other PROMs with better responsiveness for people with PHP such as the Foot Health Status Questionnaire and Foot and Ankle Ability Measure [17, 39]. However, it is important to note that all of these lack a question about first step pain which is pathognomonic for PHP and is the most prominent symptom. Developing a PROM that accurately captures the essence of the difficulties faced by people with PHP should facilitate understanding of the condition, including prognosis.

Wu et al. (2019) [30] reported that when the average pain intensity decreased by over 1.5 points with anti-pronation taping, it was associated with a favourable outcome for an orthoses intervention. Intuitively, the benefit of taping that mimics orthoses would seem logical because both interventions provide a biomechanical support on the foot to decrease stress on the plantar fascia [40, 41]. Taking into account that this factor has a high effect size (+LR=2.17 (1.19–3.90)), and anti-pronation taping is more feasible compared to orthoses applications in the first line management strategies (at a time period of 1 week), clinicians are recommended to apply taping to people who are potentially eligible for foot orthoses prescription.

The results revealed by Wu et al. (2019) [30] suggest that increased ankle plantar flexion, hip internal and external rotation angle are associated with a positive outcome from the use of foot orthoses [30]. With reference to the predictors relating to hip mobility and ankle plantar flexion, it has been postulated that these variables might be associated with an out-toeing gait, leading to an increase in medial tibial rotation and excessive foot pronation [42], which could also be targeted and controlled with foot orthoses [43]. The importance of these factors is likely driven by the key role of the plantar fascia in gait and its anatomical location meaning there are high magnitude compressive and tensile forces acting on the tissue. The degree and importance of these physical outcome predictors requires clarification and confirmation in future studies.

A shorter symptom duration with a lower frequency of pain was reported to be predictive of a favourable outcome following ESWT. However, it is important to note that the AUC value is close to the threshold of 0.50 which suggests no relevant relationship or no ability of this factor to discriminate between those with an unfavourable or favourable outcome with ESWT. Similarly, higher pain severity at baseline and longer pain duration have also shown an association with a poor prognosis in other musculoskeletal pain conditions [44]. Irrespective of the type of treatment strategy implemented for a musculoskeletal condition, these findings highlight the clinical importance of implementing an effective pain

intervention programme as early as possible in order to increase the likelihood of intervention success.

The absence of research on prognosis related to the role of psychosocial factors for people with PHP is an area where further research is needed. There is a substantial body of evidence that psychological disorders are associated with bodily pain in several musculoskeletal conditions including PHP [45–47]. Of these, emotional (e.g., depression), cognitive (e.g. catastrophisation) and behavioural (e.g. avoidance behaviours) factors have received the most attention within several case–control and cross-sectional studies [48–51]. Understanding the role of psychosocial aspects of a musculoskeletal condition will assist management strategies [11].

Additionally, developing prognostic models is a process with several steps; starting from evaluation of prognostic factors, followed by model development and validation [52, 53]. It should be emphasised that the current evidence base is relevant only to the initial stage of prognostic research, with no work yet reporting validation of a prognostic model. Therefore, second and third phase prognostic studies are clearly needed to inform clinical practice.

The most commonly found limitation across the studies was inadequate reporting of statistical and methodological approaches. These studies also did not provide estimate rates from the univariate analyses, which limited interpretation of the individual association of variables on prognosis. It is recommended that authors apply published recommendations, designed to improve the quality and transparency of prognosis research [54]. Moreover, it has been critiqued that Wu et al. (2018) [29] tested only one version of anti-pronation taping without dynamic gait analysis and the benefit of implementation of this tape or a different version in the longer term is unknown. The same group also evaluated the outcome of orthoses [30]. Although orthoses are termed customised, the authors utilised heat-mouldable preformed orthoses and the method of customisation was not described. Additionally, it was not clearly stated if the results from Wu et al. (2018) [29] and Wu et al. (2019) [30] were from the same sample.

There were limitations of the review process. First, relevant databases were thoroughly searched using keywords, but there is always the risk of missing relevant studies, particularly for single arms of intervention trials. In order to avoid missing any study, we performed double screening of RCT arms through the search returns of our recent systematic review which had sourced all RCTs of any intervention in any language [6]. Moreover, both reviewers were blinded to the authors of the papers included for appraisal [23]. Second, although this systematic review only implemented a narrative synthesis, variations in recovery definition (Table 3) could influence the interpretation of estimates

summarised across the retained studies. Therefore, these limitations should be considered during interpretation of the results. Third, previous research has used either QUADCPR or QUIPS II for the quality assessment. However, as Butner et al [23] points out, the former tool assesses methodological quality of studies whereas the latter is focusing on risk of bias. In this study, we used both QUADCPR and QUIPS II.

## Conclusion

There are limited biomedical factors which can be used to predict PHP outcomes. Having bilateral pain and being female should alert clinicians to an increased risk of a poor outcome. We identified modifiable and measurable factors such as pain status and a variety of ankle and hip kinematics, as being potential factors that predict the success of treatments such as shockwave therapy, anti-pronation taping and foot orthoses. These could assist informed clinical decisions regarding outcome expectations. To better understand PHP recovery or persistence, high quality prospective studies should evaluate the prognostic value of a range of variables, including psychosocial in addition to biological factors.

## Abbreviations

RCT	Randomized controlled trial
ESWT	Extracorporeal shockwave therapy
ROB	Risk of bias
ROM	Range of motion
FFI	Foot function index
AUC	Area under the curve
LR	Likelihood ratio
HR	Hazard ratio
BMI	Body mass index
MLA	Medial longitudinal arch
MTPJ1	First metatarsophalangeal joint
PHP	Plantar heel pain
PROMs	Patient reported outcome measures

## Supplementary Information

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### Additional file 1.

## Authors' contributions

All authors made substantial contributions to the conception, design, Manuscript preparation and delivery of the study. The author(s) read and approved the final manuscript.

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## Availability of data and materials

The datasets analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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