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Foot disease and physical function in older adults: A systematic review and meta-analysis

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Abstract

Objectives: To systematically assess the literature examining the association between foot disease (foot ulceration, infection, critical ischaemia and/or Charcot neuroarthropathy) and physical function in older adults.

Methods: Literature search of MEDLINE, Embase and CINAHL was performed. Studies were included if foot disease and physical function were assessed in participants of mean or median age ≥ 65 years.

Results: Of 2,574 abstracts screened, 19 studies (13 longitudinal, 6 cross-sectional) reporting on 5634 participants, 43% female, were included. Diabetes-related foot disease and critical ischaemia were most studied ($n = 5017$, 40% female). In 8 studies with control groups, foot disease was associated with poorer physical function. Meta-analysis of 5 studies ($n = 1503$, 45% female) found an association between foot disease and poorer physical function (SMD (95% CI): 1.00 (0.40, 1.62), $P < 0.001$).

Conclusion: Foot disease is associated with poorer physical function in older adults. Future research should include broader study populations and intervention strategies.

KEYWORDS

accidental falls, foot diseases, foot ulcer, peripheral arterial disease, physical functional performance

1 | INTRODUCTION

Foot problems, such as pain, deformity, muscle weakness and reduced range of motion, increase in prevalence with advancing age.^{1,2} Foot disease, which is defined as foot ulceration, infection, critical ischaemia and/or Charcot neuroarthropathy³, is the most severe form of foot problems and prevalent in 5 to 12% of hospital inpatients.^{1,3,4} Foot problems and foot disease are associated with poorer health outcomes.⁵ In community-dwelling older adults, foot problems have been associated with a higher risk of falling,⁶ reduced independence in activities of daily living (ADLs)^{7,8} and reduced quality of life.^{9–12} Podiatry interventions in older adults with foot problems are associated with better physical function¹³ and reduced risk of falls.¹⁴

Most studies of foot disease have been undertaken in specific disease-related populations, such as people with diabetes, rather than general populations.³ People with diabetes-related foot disease have a higher risk of falls, hospitalisation and amputation,^{15,16} and podiatry intervention has been shown to attenuate these risks.^{17,18}

It is likely that foot disease would be associated with poorer physical function in older adults. It is important to examine this association, as foot disease may be more readily diagnosed by non-podiatrists than milder foot problems, and there is potential for intervention. The aim of this study, therefore, is to systematically review the current literature to determine the association between foot disease and physical function in older adults.

2 | METHODS

The protocol of the systematic review was developed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines¹⁹ and registered with the PROSPERO International prospective register of systematic reviews (CRD42020169885). MEDLINE (from 1946), Embase (from 1974) and CINAHL (from 1937) databases were systematically searched for studies published until 23 February 2020. The search strategy was developed with the assistance of a senior research librarian and included synonyms of foot disease, physical function and older adult. Further studies were identified by searching the reference lists of included articles. The complete search strategy for each database is included in Appendix S1. Inclusion criteria were as follows: randomised controlled trials or observational studies (cross-sectional or longitudinal); diagnosis of foot disease, defined as foot ulceration, infection, critical ischaemia (toe pressure <30mmHg or Ankle Brachial Index <0.5) or Charcot neuroarthropathy; participants with and without foot disease were assessed using a measure of physical function; article published in English; and mean or median age ≥65 years. Any measure of physical function, or measure related to physical function, was accepted: falls were included, given the strong association between poorer physical function and higher risk of falls.²⁰ Studies without primary data, such as conference abstracts and reviews, were excluded.

Articles were managed with Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia; available at www.covidence.org). Titles and abstracts were independently reviewed by two reviewers (RKI, EKL). Disagreements were resolved by discussion with a third reviewer (EL). Full texts of included articles were independently assessed, and data extraction was performed by two reviewers (RKI, EKL). The quality and risk of bias of individual studies were assessed by two independent reviewers (RKI, EKL) using the Newcastle-Ottawa Scale (NOS).²¹ The NOS provides an assessment of the methodological quality of case-control and cohort studies with a maximum score of 9 points.²¹ Studies with a NOS score between 0 and 3 points were defined as low quality, 4 to 6 points as moderate quality and 7 to 9 points as high quality.²² Publication bias was examined with a funnel plot.²³

Meta-analysis was performed using Comprehensive Meta-Analysis software (version 2.0; Biostat Inc.), with a random effects model to account for heterogeneity.²⁴ Studies reporting physical function measures were compared using standardised mean difference (SMD) where the published data were sufficient to calculate SMD. For studies reporting multiple physical function measures, the mean of the SMD was used in the meta-analysis. The SMD may be interpreted as representing a small, medium or large effect size

Policy Impact

This systematic review and meta-analysis found an association between foot disease and poorer physical function in older adults. Further studies of foot disease in general populations of older adults and interventional studies aiming to attenuate the impact of foot disease on physical function are warranted.

Practice Impact

Foot disease is associated with poorer physical function in older adults. This finding adds to our knowledge of the impact of foot issues this population. Screening for foot disease should be considered in older adults.

based on the cut-off points of 0.2, 0.5 and 0.8, respectively.²⁵ Heterogeneity was expressed using the I^2 statistic (low <25%; moderate <50%; high >50%).²⁶ Reporting bias was assessed using a funnel plot.²⁷ P values below 0.05 were considered significant.

3 | RESULTS

Of 2574 articles eligible for title and abstract screening, 88 were eligible for full-text screening and 19 articles were included in the systematic review. Figure 1 shows the selection process of included articles.

Table 1 shows the descriptive characteristics of the included articles. The studies included a total of 5634 participants, and the proportion of female participants ranged from 0 to 81% (mean 43%). The study populations were community dwelling (2202 participants, 9 studies);^{28–36} hospitalised (2068 participants, 8 studies);^{37–44} institutionalised (702 participants, 1 study);⁴⁵ and mixed population (662 participants, 1 study).⁴⁶ Six studies were cross-sectional^{29–31,33–35} and 13 longitudinal.^{28,32,36–46} Eight of the 19 studies featured a control group:^{28–31,33–36} cross-sectional studies were more likely to include a control group (6 of 8 studies) than longitudinal studies (2 of 13 studies). Eight studies were undertaken in participants with diabetes-related foot disease: 6 of these studies included only participants with diabetes;^{28,30,31,37,38,40} and 2 studies also included participants without diabetes.^{29,39} Eight studies were undertaken in participants with critical limb ischaemia (CLI): 7 of these studies were revascularisation studies, comparing physical function before and after intervention;^{32,41–46} the other study compared outpatients with peripheral arterial disease of varying severity with controls.³³ The studies of foot disease due to CLI included a significant proportion of participants with diabetes (range 25–70%). Two studies were undertaken in outpatients with rheumatoid arthritis

FIGURE 1 PRISMA flow diagram [Colour figure can be viewed at wileyonlinelibrary.com]

without diabetes,^{34,35} and one study was conducted in a general cohort of older adults presenting to an emergency department, of which 21% were people with diabetes.³⁶

3.1 | Physical function

A wide range of physical function measures were reported (Table 1), including functional status (9 studies);^{29,34,35,37,39–41,45,46} ambulatory function (6 studies);^{32,33,38,42–44} physical activity (4 studies);^{28,30,32,33} residential status (3 studies);^{42–44} frailty (2 studies);^{29,46} and Health-Related Quality of Life (HRQL) (2 studies).^{31,46} One study reported falls.³⁶

Table 2 summarises the association between foot disease and physical function. All eight studies that included a control group reported significantly poorer physical function in participants with foot disease. These differences were reported for: functional status (Stanford Health Assessment Questionnaire (HAQ) and Foot Impact Scale (FIS) scores);^{29,34,35} physical activity (daily step count,²⁸ daily activity unit scores,³³ Summary Performance Score³³); self-reported activity (more sitting time; lower likelihood of undertaking vigorous exercise);³⁰ frailty (Edmonton Frail Scale);²⁹ HRQL (Short-Form 36 Health Survey scores);³¹ and falls.³⁶

Studies without a control group included participants with diabetes-related foot disease and CLI having hospitalisation or surgical intervention for their foot disease. Participants

with diabetes-related foot disease had high rates of functional impairment measured by Barthel Index (BI)^{37,40} and Functional Independence Measure (FIM).³⁹ Participants with foot disease due to CLI reported high rates of functional impairment and reduced ambulatory capacity, with limited improvement in these domains after intervention.^{32,41–44,46}

3.2 | Other outcomes reported

Table 2 shows other outcomes reported by the included studies: amputation rate was reported by 2 studies;^{37,38} institutionalisation rates were reported by 4 studies,^{39,42–44} and mortality was reported by 10 studies;^{32,37–44,46} none of these studies included a control group. Institutionalisation rates ranged from 11% in a study of patients undergoing major amputation for foot disease³⁹ to 28% in a study of nonagenarians undergoing treatment for CLI-related foot disease.⁴³ Mortality ranged from 0% in a small study of 3- to 4-month follow-up³² to 97% at 5 years in the aforementioned nonagenarian study.⁴³

3.3 | Quality assessment

Table 3 presents the risk of bias quality assessment for included studies based on the Newcastle-Ottawa Scale (see

TABLE 1 Study characteristics of included articles

First author, Year (Ref)	Study design	N	Population	Age, years	Female, %	Follow-up, months	Physical Function	Physical function measure(s)
Populations with diabetes								
Armstrong, 2004 ²⁸	L, O, P	100	Outpatients with risk factors for foot disease (excluded PAD)	68.5 (10)	5	8.4 (2.8)	Daily activity Activity clusters	Step count CV of activity
Boas, 2018 ²⁹	C	150	Outpatients with & without FU; controls without diabetes	Range 67.7–71.5	56	N/A	Frailty Functional disability	EFS HAQ
Chu, 2016 ³⁷	L, O, P	245	Toe amputation for DFU	69.3 (9.4)	41	60	ADL	BI
Hartmann, 2017 ³⁸	L, O, R	245	Hospitalised for DFS	71	16	6	Mobility at discharge	Non-validated measure: mobile vs immobile
Hershkovitz, 2013 ³⁹	L, O, P	117	Lower limb amputation (61% DFS) admitted to rehabilitation	74.7 (8.1)	39	12	Prosthesis use Functional status by prosthesis group	Prosthesis yes/no FIM
Johnson, 2019 ³⁰	C	240	Community based, past history of FU or no FU (no active FU)	68.7 (10.5)	42	N/A	Self-reported physical activity	IPAQ-SF
Seker, 2016 ⁴⁰	L, O, R	87	TTA or TFA for DFU	TTA 69.3 TFA 70.7	36	79.1	Functional status by amputee group	BI, AMP
Valensi, 2005 ³¹	C	335	With and without DFU	DFU 65.5 (11.2) no- DFU 62.3 (12.7)	38	N/A	HRQL	SF-36 Diabetic Foot Ulcer Scale
Populations with critical lower limb ischaemia								
Duggan, 1994 ⁴¹	L, O, R	38	Limb salvage surgery (70% with diabetes)	72.1	45	18.6	Functional status	RAND-36
Gardner, 2001 ³²	L, O	20	Lower limb revascularisation (70% with diabetes)	68	0	3	Before and after revascularisation: Ambulatory function Physical activity Self-reported physical activity	20MWT, 6-min walk test Steps/day PAD-PAR, LTPA, WIQ
Iida, 2017 ⁴⁶	L, O, P	662	With or without revascularisation (R + vs R-) (62% with diabetes)	77 (10) R+ 82 (9) R-	41 R+ 59 R-	12	ADL Frailty HRQL	Modified KATZ index Life-Space Assessment 5m gait velocity Grip strength EQ-5D EuroQol VAS

(Continues)

TABLE 1 (Continued)

First author, Year (Ref)	Study design	N	Population	Age, years	Female, %	Follow-up, months	Physical Function	Physical function measure(s)
McDermott, 2002 ³³	C	740	Outpatients with PAD and controls (28% with diabetes)	70.9 (8.4)	44	N/A	Ambulatory function Physical activity	6-min walk test Summary performance score Activity units/day
Pomposelli, 1998 ⁴²	L, O, R	262	Undergoing LEAR (67% with diabetes)	83.6	55	12	Residential status Ambulatory function	Non-validated measures
Saارينen, 2015 ⁴³	L, O, R	233	CLI (n = 170) or acute limb ischaemia (n = 63) having vascular intervention (25% with diabetes)	92 (median)	81	NR	Residential status Ambulatory function	Non-validated measures
Taylor, 2006 ⁴⁴	L, O, R	841	Vascular intervention (54% with diabetes)	68.1 (12.1)	43	27.5 (21.6)	Residential status Ambulatory function	Non-validated measures
Vogel, 2014 ⁴⁵	L, O, R	702	Nursing home residents having revascularisation (63% with diabetes)	NR	57	6	ADL	Minimum Data Set ADL-Long form score
Populations with Rheumatoid arthritis (RA)								
Firth, 2008 ³⁴	C	81	Outpatients with FU (n = 15) or no FU (n = 66) (0% with diabetes)	65 (13) FU+	27 FU+	N/A	Functional disability	Foot impact scale HAQ
Firth, 2014 ³⁵	C	273	Outpatients with FU (n = 83) or no FU (n = 190) (0% with diabetes)	71 FU+ 62 FU-	79	N/A	Functional disability	Foot impact scale HAQ
General population older adults								
Carpenter, 2009 ³⁶	L, O, P	263	Community dwelling, presenting to emergency (21% with diabetes)	76	63	6	Falls	Self-reported fall

Note: Abbreviations: (), standard deviation; [], interquartile range; ADL, Activities of Daily Living; AMP, Amputee Mobility Predictor; BI, Barthel Index; C, cross-sectional; CLI, Critical Limb Ischaemia; CV, Coefficient of variation; DFS, Diabetic Foot Syndrome; DFU, Diabetic Foot Ulcer; EFS, Edmonton Frail Scale; EQ-5D, EuroQol 5 Dimension; EuroQol VAS, EuroQol Visual Analogue Scale; FIM, Functional Independence Measure; FU, foot ulcer; HAQ, Stanford Health Assessment Questionnaire; HRQL, Health-Related Quality of Life; IPAQ-SF, International Physical Activity Questionnaire Short Form; L, longitudinal; LEAR, Lower Extremity Arterial Reconstruction; LTPA, Minnesota Leisure Time Physical Activity; NR, not reported; O, observational; P, prospective; PAD-PAR, Peripheral Arterial Disease Physical Activity Recall; PAD, Peripheral Arterial Disease; R, retrospective; RAND-36, RAND-36 Item Health Assessment Survey Version 1.0; SF-36, Short-Form 36 Health Survey; TFA, trans-femoral amputation; TTA, trans-tibial amputation; WIIQ, Walking Impairment Questionnaire; 20MWT, 20-metre walk test.

TABLE 2 Reported study outcomes of included articles

First author, Year (Ref)	Physical Function	Physical Function Measures	Outcome	Other outcomes reported
Populations with diabetes				
Armstrong, 2004 ²⁸	Physical activity Activity clusters	Step count, steps/day (SD) CV of activity, % (SD)	8% developed FU Lower daily activity and higher CV of activity in FU group 809.0 (612.2) FU+; 1394.5 (868.5) controls; $P = .03$ 96 (50) FU+; 45 (15) controls; $P = .02$	
Boas, 2018 ²⁹	Frailty Functional disability	EFS severity, n (%) HAQ, mean (SD)	DFU group more frail and greater functional disability 15 (30%) D + FU+; 1 (2%) D + FU-, 0 (0%) D-FU-; $P < .001$ 2.4 (0.6) D + FU+; 0.5 (0.9) D + FU-; 0.2 (0.5) D-FU-; $P < .001$	
Chu, 2016 ³⁷	ADL	BI, dichotomised, n (%)	32% moderate/severe ADL impairment; higher re-amputation incidence if moderate/severe ADL impairment BI > 60 (good/mild dysfunction) 126 (68%) BI < 60 (moderate/severe dysfunction) 59 (32%)	Re-amputation 49% Mortality 38%
Hartmann, 2017 ³⁸	Mobility at discharge	Mobile, %, by age group	Mobility decreased with age; didn't improve with revascularisation 80% < 65 years; 71% 65–74 years; 58% 75 years; 53% 84 years	Amputation 3% Mortality 9%
Hershkovitz, 2013 ³⁹	Prosthesis use Functional status	Prosthesis suitable, n (%) FIM, mean (SD)	Higher FIM scores in prosthesis group 27 (23%) Admission 73.6 (14.3) Discharge 90.8 (13.7) Prosthesis + Admission 50.4 (17.4) Discharge 55.7 (22.4) Prosthesis –	Mortality 46% Institutionalisation 11%
Johnson, 2019 ³⁰	Self-reported physical activity	Walking time, min/wk Moderate exercise, min/wk Vigorous exercise, min/wk Sitting time, min/wk Moderate exercise, Yes/No Vigorous exercise, Yes/No PA guidelines met, Yes/No	13% had a history of FU Correlation (R) with history of FU –0.0, NS Correlation (R) with history of FU –0.0, NS Correlation (R) with history of FU –0.1, NS Correlation (R) with history of FU 0.2, $P < .05$ Phi coefficient with history of FU 0.1, NS Phi coefficient with history of FU –0.1, $P < .05$ Phi coefficient with history of FU –0.1, NS	
Seker, 2016 ⁴⁰	Functional status	BI, mean AMP, mean	TTA 82.5; TFA 80.2, NS TTA 32.3/29.5 prosthesis±; TFA 26.9/22.7 prosthesis±; $P < .05$	Mortality 66%

(Continues)

TABLE 2 (Continued)

First author, Year (Ref)	Physical Function	Physical Function Measures	Outcome	Other outcomes reported
Valensi, 2005 ³¹	HRQL	SF-36	Poorer HRQL in DFU group in all SF-36 domains, $P < .001$ Age, type of diabetes, DFU severity (Wagner grade) and number of FU significant and independent predictors of HRQL impairment	
Populations with critical lower limb ischaemia				
Duggan, 1994 ⁴¹	Functional status	RAND-36, pre-operative compared to post-operative	Deterioration in general health and mobility after surgery, lower scores post-operatively in all domains except pain	Mortality 39%
Gardner, 2001 ³²	Ambulatory function Physical activity Self-reported physical activity	20MWT, m/s, mean (SD) 6-min walk, m, mean (SD) Steps/day, mean (SD) WIQ distance; speed; stairs (%) PAD-PAR, MET-h/day, mean (SD) LTPA, Kcal/day, mean (SD)	Measured physical activity did not change; significant improvement in self-reported ambulatory and physical activity Before and after revascularisation: 0.9 (0.1), 1.0 (0.1), $P = .92$ 85 (9), 101 (11), $P = .74$ 2921 (1030), 2643 (1155), $P = .88$ 7 (2%), 26 (7%); 9 (4%), 25 (7%); 12 (5%), 29 (8%); all $P < .001$ 41 (5), 105 (7), $P < .001$ 58 (8), 136 (22), $P < .001$	Mortality 0%
Iida, 2017 ⁴⁶	ADL Frailty HRQL	Modified KATZ index, mean (SD) Life-Space Assessment, mean (SD) 5m gait, velocity > 10sec, % Grip strength $\leq 15/\leq 10$ M/F, % EQ-5D, mean (SD) EuroQol VAS, mean (SD)	Non-revascularised group older, frailer HRQL significantly improved in revascularised group, ADL did not Revascularised (R+) vs non-revascularised (R-) at baseline; R+ at 1 year 2.8 (2.4) vs 1.4 (2.0), $P < .001$; 2.3 (2.4) 19 (22), 10 (17), $P < .001$; 18 (25) 13.9, 9.0, $P < .001$; NR 31.7, 47; NR 0.4 (0.3), 0.3 (0.3); 0.4 (0.3) 43 (22), 39 (24), $p 0.18$; 55 (25)	Mortality 34%

(Continues)

TABLE 2 (Continued)

First author, Year (Ref)	Physical Function	Physical Function Measures	Outcome	Other outcomes reported
McDermott, 2002 ³³	Ambulatory function Physical activity Lower extremity function	Stops on 6-min walk 6-min walk, feet 4m walk velocity, m/s Activity units/day Summary performance score Tandem stance hold 10s	Participants with CLI had worse physical function than controls OR (95%CI) 11.7 (4.9-27.7), $P < .001$ Regression coefficient (95%CI) -523 (-592 to -454), $P < .001$ Regression coefficient (95%CI) -0.21 (-0.27 to -0.15), $P < .001$ Regression coefficient (95%CI) -515 (-657 to -373), $P < .001$ Regression coefficient (95%CI) -1.7 (-2.14 to -1.26), $P < .001$ OR (95% CI) 0.37 (0.18 to 0.76), $p 0.007$	
Pomposelli, 1998 ⁴²	Residential status Ambulatory function	Non-validated measure Score 1-4, mean Score 1-4, mean	Ambulatory function score worsened post-operatively Pre-operative vs post-operative 1.8, 1.9, $P < .05$ 1.6, 1.7, $P < .05$	Mortality 56% Institutionalisation 10%
Saarin, 2015 ⁴³	Residential status Ambulatory function	Non-validated measure Living in home-like circumstances, % Ambulatory (with/without aid), %	Worse residential status and ambulatory function post-operatively; Pre-operative vs post-operative: 83, 72 91, 82	Mortality 97% Institutionalisation 28%
Taylor, 2006 ⁴⁴	Ambulatory function and living status	Non-validated measure Change in ambulatory status, % Independence maintained, %	Premorbid impaired ambulation and dementia predictors of poor function 29 81	Mortality 58% Institutionalisation 19%
Vogel, 2014 ⁴⁵	Functional status	Minimum Data Set ADL-Long form score, change in score at 6 months by baseline ADL group	Most patients had ADL limitations prior to hospitalisation; these deteriorated during hospitalisation by 3 points and at 6 months had improved by 5-8 points Mean ADL function improved 1.6 points per month after hospital discharge	

Populations with Rheumatoid arthritis (RA)

Firth, 2008³⁴ Functional disabilityFoot impact scale
HAQMann-Whitney U scores comparing groups:
Higher score FU group, $U = 302.5$, $P = .01$
Greater reduction self-care capacity FU group.
 $U = 351.5$, $P = .05$

(Continues)

TABLE 2 (Continued)

First author, Year (Ref)	Physical Function	Physical Function Measures	Outcome	Other outcomes reported
Firth, 2014 ³⁵	Functional disability	Foot impact scale, mean (SD), OR (95% CI) HAQ, mean (SD), OR (95% CI)	Worse functional status in FU group FU vs control group 34.5 (10.9), 27.4 (13.8), 1.1 (1.0 - 1.1) 1.9 (0.9), 1.5 (0.9), 1.7 (1.3 - 2.3)	
General population older adults				
Carpenter, 2009 ³⁶	Falls	Reported fall during follow-up period	8% had a FU; FU associated with increased risk of falling Cox regression analysis HR 3.71 (95%CI 1.73-7.95)	

Abbreviations: ADL, Activities of Daily Living; AMP, Amputee Mobility Predictor; BI, Barthel Index; CLI, Critical Limb Ischaemia; CV, Coefficient of variation; D, Diabetic; DFS, Diabetic Foot Syndrome; DFU, Diabetic Foot Ulcer; EFS, Edmonton Frail Scale; EQ-5D, EuroQol 5 Dimension; EuroQol VAS, EuroQol Visual Analogue Scale; FIM, Functional Independence Measure; FU, foot ulcer; HAQ, Stanford Health Assessment Questionnaire; HRQL, Health-Related Quality of Life; IPAQ-SF, International Physical Activity Questionnaire Short Form; LEAR, Lower Extremity Arterial Reconstruction; LTPA, Minnesota Leisure Time Physical Activity; m, metres; Min, minutes; NR, not reported; NS, not significant; PA, Physical activity; PAD-PAR, Peripheral Arterial Disease Physical Activity Recall; PVD, Peripheral Vascular Disease; RAND-36, RAND-36 Item Health Assessment Survey Version 1.0; s, seconds; SF-36, Short-Form 36 Health Survey; TFA, trans-femoral amputation; TTA, trans-tibial amputation; wk, week; WIQ, Walking Impairment Questionnaire; 20MWT, 20-metre walk test.

Appendix S2). Two studies were of high quality,^{33,46} 16 studies were of moderate quality,^{28-32,34-42,44,45} and 1 study was of low quality.⁴³

3.4 | Meta-analysis

Of the 8 studies reporting physical function measures for both foot disease and control groups, 5 studies (n = 1503) were included in the meta-analysis.^{28-30,33,35} The meta-analysis (shown in Figure 2) found significantly poorer physical function in patients with foot disease: SMD (95% CI): 1.00 (0.40, 1.62), $P < 0.001$. There was high heterogeneity ($I^2=96\%$). There was asymmetry in the funnel plot, suggesting presence of reporting bias.^{23,27}

4 | DISCUSSION

This systematic review found an association between foot disease and poorer physical function. Foot problems (incorporating foot pain and deformity) have been associated with poorer physical function in older adults, as measured by ADL independence,^{7,8} quality of life⁹ and falls.² Given that foot disease represents more severe foot pathology than foot problems, a greater association with poorer physical function may be anticipated. An association between foot disease and lower physical activity has also been shown in studies of younger cohorts with diabetes-related foot ulceration⁴⁷, as well as high disability burden⁴⁸ and risk of lower limb amputation.⁴⁹

Most studies were undertaken in specific disease-related populations with diabetes-related foot disease or critical ischaemia; however, prevalence studies suggest that foot disease is also common in populations without diabetes and hospitalised older adults.^{3,4} An Australian survey in general hospital inpatients (mean age 62 years) reported prevalence of foot disease of 10%, only 46% of whom were people with diabetes.¹ Similarly, in a retrospective study of patients admitted to a US hospital with foot ulceration only 54% had diabetes-related foot disease.⁵⁰

The studies of foot disease populations without control groups reported poor physical function as well as high institutionalisation and mortality rates among participants.^{32,37-46} Institutionalisation rates were comparable to reported rates for older patients with other common admission diagnoses, such as hip fracture,⁵¹ stroke or functional decline requiring hospital admission.⁵² Mortality rates in foot disease populations were higher than reported rates for these other common admission diagnoses.^{51,52}

The association between foot disease and poorer physical function does not necessarily imply causation, particularly given most of the studies with a control group were

TABLE 3 Risk of bias quality assessment (Newcastle-Ottawa Scale)

First author, year	Selection		Comparability			Outcome		Score	Quality	
	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Outcome not present at start	Adjustment for confounders	Assessment of outcome	Adequacy of duration of follow-up			Adequacy of completeness of follow-up
Armstrong, 2004	–	+	+	+	–	+	+	+	6	Moderate
Boas, 2018	–	+	+	–	+	+	–	+	5	Moderate
Carpenter, 2009	+	+	+	+	–	+	+	–	6	Moderate
Chu, 2016	–	–	+	+	–	+	+	+	5	Moderate
Duggan, 1994	–	–	+	–	–	+	+	+	4	Moderate
Firth, 2008	–	+	+	–	–	+	–	+	4	Moderate
Firth, 2014	–	+	+	–	–	+	–	+	4	Moderate
Gardner, 2001	–	–	+	+	–	+	–	+	4	Moderate
Hartmann, 2017	–	–	+	+	–	–	+	+	4	Moderate
Hershkovitz, 2013	–	–	+	–	–	+	+	–	3	Moderate
Iida, 2017	–	–	+	+	++	+	+	+	7	High
Johnson, 2019	–	+	+	–	–	+	–	+	4	Moderate
McDermott, 2002	+	+	+	–	++	+	+	+	7	High
Pomposelli, 1998	–	–	+	+	–	–	+	+	4	Moderate
Saarinén, 2015	–	–	+	+	–	–	–	+	3	Low
Seker, 2016	–	–	+	–	–	+	+	+	4	Moderate
Taylor, 2006	–	–	+	+	–	–	+	+	4	Moderate
Valensi, 2005	–	+	+	–	+	+	–	+	5	Moderate
Vogel, 2014	–	–	+	+	–	+	+	+	5	Moderate

FIGURE 2 Meta-analysis of studies reporting physical function in groups with and without foot ulceration, standardised mean difference (random effects model, $I^2 = 95.5\%$)

cross-sectional.^{29–31,33–35} There are a number of reasons, however, that physical function may be poorer in the presence of foot disease. Foot pain, which is usually a symptom of foot disease,⁵³ has been associated with higher risk of falls, impaired balance, gait abnormalities and reduced independence in ADLs.^{6,54} Critical ischaemia, one form of foot disease, is associated with reduced balance and physical activity.³³

The findings of this review highlight the importance of diagnosing foot disease, as well as the need for further studies of foot disease in general populations of older adults. Given that podiatry intervention has been shown to reduce the risk of falls for older adults with foot problems¹⁴ and to reduce amputation and hospitalisation rates in people with diabetes,^{17,18} interventional studies aiming to improve physical function in older adults with foot disease may be warranted.

4.1 | Strengths and limitations

To the best of our knowledge, this is the first systematic review investigating the association between foot disease and physical function in older adults. There was evidence of reporting bias based on the funnel plot, which is a limitation of this study: reasons for this include the possibility of unpublished negative studies and restricting articles to those published in English. Heterogeneity in the meta-analysis was high due to differences in study populations and range of outcome measures. This was addressed using a random effects analysis but must be considered in interpreting the results. A broad definition of physical function measures was used for this meta-analysis, including falls. Although falls are strongly associated with poorer physical function, other factors may also increase the risk of falling.²⁰ Comparing physical function outcomes using SMD, and use of the mean SMD for studies with multiple outcome measures, allowed comparison between studies using different measures to provide a pooled estimate of effect; however, this technique may have led to under- or over-estimate of the association²⁵ and is another limitation of this review.

5 | CONCLUSIONS

Foot disease is associated with poorer physical function in older adults. Most studies to date have included specific disease-related cohorts of patients and reported a range of physical function measures. Future research should include broader study populations with control groups without foot disease.

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CONFLICTS OF INTEREST

No conflicts of interest to declared.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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