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Human Kinetics
SCHOLARLY REVIEW

Risk Factors for Mobility Decline in Community-Dwelling Older Adults: A Systematic Literature Review

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Mobility is essential to maintaining independence for older adults. This systematic review aimed to summarize evidence about self-reported risk factors for self-reported mobility decline; and to provide an overview of published prognostic models for self-reported mobility decline among community-dwelling older adults. Databases were searched from inception to June 2, 2020. Studies were screened by two independent reviewers who extracted data and assessed study quality. Sixty-one studies (45,187 participants) were included, providing information on 107 risk factors. High-quality evidence and moderate/large effect sizes for the association with mobility decline were found for older age beyond 75 years, the presence of widespread pain, and mobility modifications. Moderate–high quality evidence and small effect sizes were found for a further 21 factors. Three model development studies demonstrated acceptable model performance, limited by high risk of bias. These findings should be considered in intervention development, and in developing a prediction instrument for practical application.

Keywords: mobility disability, predictors, self-reported

Mobility is defined as "the ability to move oneself within community environments that expand from one's home, to the neighborhood, and to regions beyond" (Webber, Porter, & Menec, 2010). Maintaining mobility is fundamental to aging well for older adults (Guralnik et al., 1993). Limited mobility is linked to functional decline, mortality, and increased health care costs (Guralnik et al., 1993). Changes in mobility are important as conceptually they precede disability within models of disablement and are potential targets for rehabilitation (Verbrugge & Jette, 1994).

Mobility may be assessed using objective or self-reported measures. While it is acknowledged that different aspects of mobility may be measured with each, multiple studies have found a moderate correlation between the two approaches (Alexander et al., 2000; Syddall, Westbury, Cooper, & Sayer, 2015). Self-reported mobility is important as it is the most commonly used measure clinically (Chung, Demiris, & Thompson, 2015). Objective physical performance measures do not reflect the individual's perceptions about their own mobility, and are most often conducted in a supervised, controlled environment, thus unreflective of a real-world situation. Potential risk factors for mobility decline may also be measured objectively or by self-report. Self-reported measures of these factors are also important, as they have low response burden, can capture both current and historical information, and can assess psychological and social factors.

Two previous reviews of risk factors for mobility decline combined objective and self-reported measures of risk factors and mobility, but these were narrative rather than systematic reviews (Rantakokko, Mänty, & Rantanen, 2013; Yeom, Fleury, & Keller, 2008). Consolidated evidence of self-reported risk factors contributing to self-reported mobility decline is needed to inform clinical decision making and to inform the development of a prognostic tool to help clinicians and researchers identify older adults at risk of mobility decline. The primary objective of this systematic review was to synthesize available evidence for self-reported factors which predict decline in self-reported mobility after 12 months to 5 years of follow-up among community-dwelling older adults. The secondary objective was to identify, describe, and synthesize the predictive accuracy of prognostic models developed to predict risk of self-reported mobility decline in community-dwelling older adults.

Methods

This systematic review is registered at the International Prospective Register of Systematic Reviews database (PROSPERO 2019 CRD42019135420. Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019135420). The review is reported according to the Preferred Reporting Items for Systematic Review and Meta-Analyses guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), and the CHecklist for critical Appraisal and data extraction for systematic Reviews of prediction Modelling Studies (CHARMS) (Moons et al., 2014).

Search Strategy

The search strategy was developed conjointly with an information scientist (SK). We searched the MEDLINE (via OVID), EMBASE

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(via OVID), PsycINFO (via OVID), and CINAHL (via EBSCOhost) databases to identify studies that assessed the predictive value of self-reported risk factors on self-reported mobility decline. Search terms included controlled vocabulary (e.g., MeSH) terms and free-text terms. No date or language limits were applied to the search. The search strategy for MEDLINE is presented in Supplementary Table S1 (available online), and this was translated to the relevant controlled vocabulary headings and syntax for each database. The search was conducted on June 26, 2019, with an update run on June 2, 2020. Supplementary searches of the reference and citation lists of included studies and relevant systematic reviews were undertaken to identify additional eligible studies.

Study Selection

Inclusion criteria.

- Studies involving community-dwelling older adults with a minimum mean age of 60 years at recruitment.
- Longitudinal cohort studies evaluating the ability of self-reported factors to predict self-reported mobility decline. Randomized controlled trials were eligible if they provided appropriate data and treatment-effect modification analyses were reported.
- Prognostic model studies, with or without validation. Models had to contain at least two self-reported risk factors, and include age and sex as a minimum of adjustment factors.
- A self-reported measure of mobility, defined as difficulty with walking and/or difficulty in climbing stairs and/or life-space assessment, assessed at baseline and follow-up.
- A clear definition of mobility decline.
- Where a study collected both self-reported measures and objective measures, the study was eligible if data reported the relationship between self-reported measures and self-reported outcomes.
- Follow-up period of between 12 months and 5 years.
- Published in English, Spanish, or Portuguese (languages spoken by the research team).

Exclusion criteria.

- Studies including only patients with a specific medical condition (e.g., Parkinson's disease, dementia, stroke).
- Studies conducted in residential aged care settings.
- Studies published in abstract form only.

Search results were imported into Covidence (Veritas Health Innovation, Melbourne, Australia, www.covidence.org) for screening. Titles and abstracts of all identified citations were independently screened by two reviewers (PN and MS). Following title and abstract screening, the full text of all potentially eligible articles was retrieved and screened independently by the same two reviewers. Inclusion disagreements were resolved through discussion, with an adjudicator (PN and MS) available.

Data Extraction

A data extraction form in Microsoft Excel (Microsoft Corporation, Redmond, WA) was developed and piloted independently by two reviewers before independent data extraction from all articles (PN and MS). Disagreements were resolved by discussion.

Studies were categorized as etiological, predictor finding, or model development using the following definitions (Moons, Royston, Vergouwe, Grobbee, & Altman, 2009):

- Etiological studies: A study examining causal association between predefined risk factor/s and mobility decline.
- Predictor finding studies: A study examining the contribution of multiple risk factors to predict mobility decline, without quantification of the predictive ability of the model.
- Model development studies: A study that aimed to develop a multivariable prediction model, assigning weighting to each identified risk factor and developing a final prediction model. These studies may or may not include internal validation studies.

Data extracted from all studies included: country of origin, year of study conduct, recruited and analyzed sample sizes, study design, type of study, length of follow-up, and participant characteristics (population source and setting, eligibility criteria, recruitment method, and sociodemographic characteristics). Method of assessment was recorded for each risk factor and mobility outcome.

For etiological studies, we extracted data for the specific risk factor/s of interest as stated in the study. For predictor finding studies, we extracted data on all included risk factors. We extracted unadjusted and adjusted effect estimates (odds ratio [OR], relative risk [RR], or hazard ratio [HR]) and corresponding *SE* or confidence intervals for each risk factor. For model development studies, we extracted modeling method, handling of risk factors and missing data, method for selection of risk factors, model performance measures, and model evaluation. We contacted authors when insufficient information was reported.

Assessment of Risk of Bias in Included Studies

Two reviewers (PN and MS) independently assessed the risk of bias in included studies using the Quality In Prognosis Studies tool for etiological and predictor finding studies and the Prediction model Risk of Bias Assessment Tool for model development studies (Hayden, van der Windt, Cartwright, Cote, & Bombardier, 2013; Wolff et al., 2019).

The Quality In Prognosis Studies tool assesses risk of bias across six domains: study participation, study attrition, risk factor measurement, outcome measurement, study confounding, and statistical analysis and reporting (Hayden et al., 2013). Each domain was rated as low, moderate, or high risk of bias (Hayden et al., 2013). The Prediction model Risk of Bias Assessment tool includes 20 signaling questions grouped within four domains (participant selection, predictors, outcome, and analysis) to evaluate the risk of bias of prediction models (Wolff et al., 2019). Studies were classified as low risk of bias if all domains were rated as low risk of bias. Any disagreements in scoring were resolved through discussion.

Data Synthesis and Analysis

Descriptive characteristics of all included studies were summarized and assessed for suitability for meta-analysis by considering the clinical heterogeneity of included studies based on population, definition of risk factors and/or mobility decline, and methodology (Riley et al., 2019). Adjusted effect estimates (minimum adjustment for age and gender/sex) were reported in the narrative analysis. Odds ratios of 1.4–2.5 were considered as small effect, 2.5–4.25 were classified as moderate, and 4.25 or greater as large (Chinn, 2000). Odds ratios were considered to indicate no association if the 95% confidence interval crossed 1.0. Information from risk factor and prognostic model studies were evaluated separately because their objectives and model-building methods are different (van den Berg et al., 2013). Performance of prognostic models were summarized and presented narratively.

Narrative Analysis

We applied the following criteria proposed by Hayden, Tougas, Riley, Iles, and Pincus (2014) to categorize the consistency of evidence for each risk factor. Consistent evidence defined as two or more studies from two or more cohorts with ≥75% of studies showing the same direction of effect (i.e., four studies from three cohorts, of which three studies show the same direction of effect). Limited evidence defined as: single study or multiple studies from the same cohort. Inconsistent evidence defined as: two or more studies from two or more cohorts with <75% of studies showing the same direction of effect (i.e., four studies from three cohorts, of which two studies show the same direction of effect).

Assessment of Quality of Evidence

The quality of the body of evidence was synthesized using the Grading of Recommendations Assessment, Development and Evaluation approach modified for use in reviews of risk factor studies (Huguet et al., 2013). Overall quality of evidence was rated as high, moderate, low, or very low considering study limitations, inconsistency of results, indirectness, imprecision, publication bias, moderate/large effect size, and the presence of a dose effect.

Results

Study Selection

The process of study selection is shown in Figure 1. In total, 26,079 citations (18,201 with duplicates removed) were identified. Of these, 187 articles progressed to full-text review, and 61 studies were included in the review. Among included studies, 47 were classified as etiological studies, 11 as predictor finding studies, and three were model development studies.

Characteristics of Included Studies

Characteristics and details of the 61 included studies are presented in Supplementary Table S2 (available online). Studies were published between 1993 and 2019. A total of 45,187 participants were analyzed. Included studies were all secondary analyses of data derived from 25 established cohorts. The cohorts from which the highest number of studies originated were the Nordic Research on Ageing Study (11 studies; Avlund, Damsgaard, & Osler, 2004; Avlund, Damsgaard, Sakari-Rantala, Laukkanen, & Schroll, 2002; Avlund, Davidsen, & Schultz-Larsen, 1995; Avlund, Lund, Holstein, & Due, 2004; Avlund, Osler, Damsgaard, Christensen, & Schroll, 2000; Avlund, Pedersen, & Schroll, 2003; Avlund, Vass, & Hendriksen, 2003; Jørgensen, Lund, Siersma, & Nilsson,

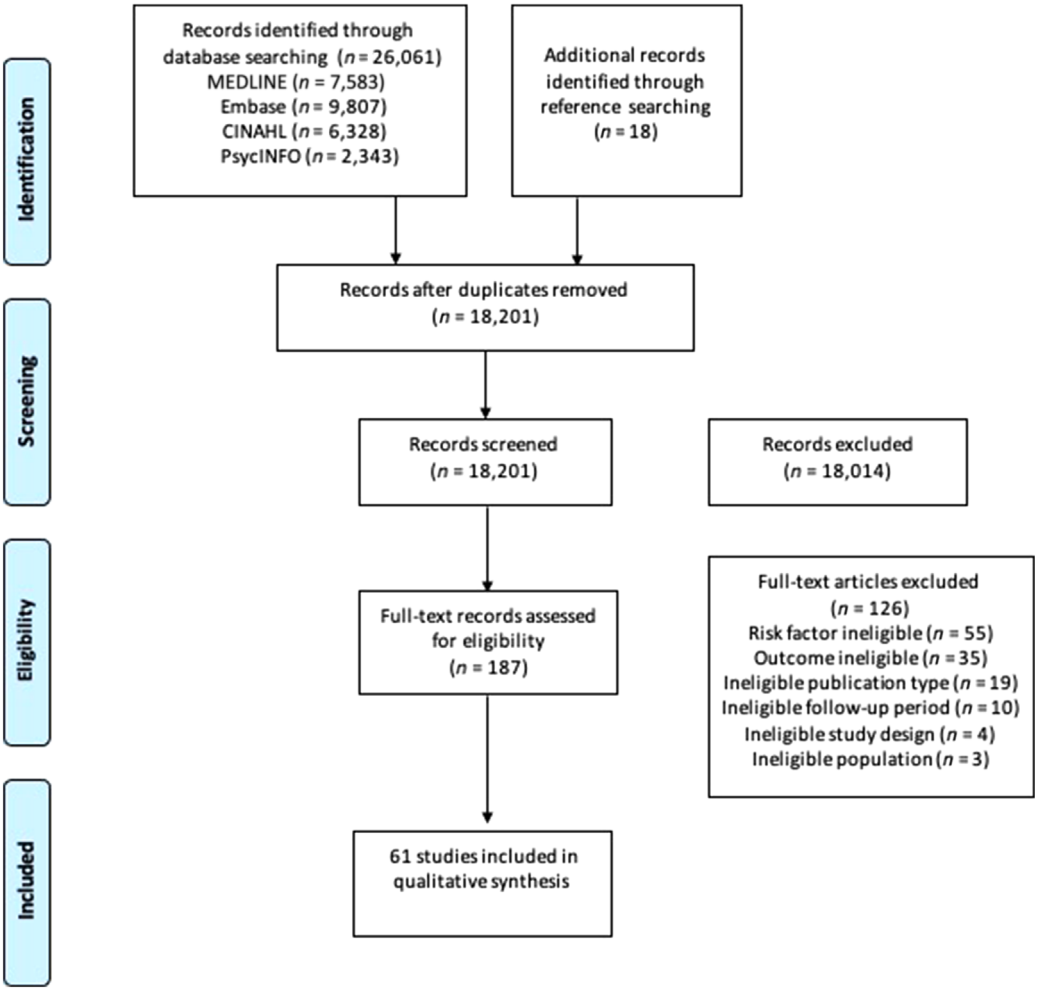

Figure 1 — Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

2017; Nilsson, Avlund, & Lund, 2010; Nilsson, Lund, & Avlund, 2008; Schroll, Avlund, & Davidsen, 1997), the Health, Ageing and Body Composition Study (seven studies; Carbone et al., 2013; Duan-Porter et al., 2019; Koster et al., 2005; Lee et al., 2005; Mehta et al., 2007; Thorpe et al., 2011; Visser et al., 2005), and the first Women's Health and Ageing Study (four studies; Brenes et al., 2005; Leveille, Bean, Ngo, McMullen, & Guralnik, 2007; Leveille et al., 2001; Onder et al., 2003). The majority of studies were based on populations from the United States (27 studies; 11 cohorts) or Finland (16 studies; five cohorts).

Age and sex characteristics. The analyzed sample size of included studies ranged from 136 to 6,981 participants. The mean of the mean ages of participants at baseline was 74.3 years. Mean ages at baseline ranged from 64 to 80 years. The gender distribution of participants varied: nine studies (Brenes et al., 2005; Chaves, Garrett, & Fried, 2000; Fried, Bandeen-Roche, Chaves, & Johnson, 2000; Leveille et al., 2001, 2007; Manty et al., 2009; Onder et al., 2003; Viljanen et al., 2012; Weiss, Wolff, Egleston, Seplaki, & Fried, 2012) (from four cohorts) reported data for women only, and three studies (Avlund et al., 1995; Liljas et al., 2016; van den Brink et al., 2004) (from two cohorts) reported data for men only. Among studies reporting on mixed-gender populations, the proportion of women varied from 46% to 75%.

Measures of mobility and mobility decline. Thirty-three different measures of mobility were used. The two most commonly used were the Mobility-Help (Mobility-H) scale (11 studies; Avlund, Damsgaard, & Osler, 2004; Avlund et al., 1995, 2000, 2002; Avlund, Lund, et al., 2004; Avlund, Pedersen, & Schroll, 2003; Avlund, Vass, & Hendriksen, 2003; Jørgensen et al., 2017; Nilsson et al., 2008, 2010; Schroll et al., 1997) and the single-item question "Do you have any difficulty walking 1/4 mile/400 m or climbing 1 flight of stairs/10 steps without assistance?" (10 studies; Auais et al., 2018, 2019; Chen, Covinsky, Stijacic Cenzer, Adler, & Williams, 2012; Deshpande, Metter, Guralnik, Bandinelli, & Ferrucci, 2014; Eggermont et al., 2014; Koster et al., 2005; Lee et al., 2005; Mehta et al., 2007; Thakral, Shi, Shmerling, Bean, & Leveille, 2014; Thorpe et al., 2011). Almost all included studies (59/61; 97%) used mobility outcomes that focused solely on walking and/or climbing stairs. Only two studies (Polku et al., 2015; Tsuji, Rantakokko, Portegijs, Viljanen, & Rantanen, 2018) used the Life Space Assessment which includes ability to move beyond one's neighborhood and/or town by means, such as public transport or driving. There was also variability in the definition of mobility decline. Among studies using the Mobility-H scale, mobility decline was defined in three different ways, most commonly by progression from "0 activities requiring help" at baseline to "need help in at least one activity" at follow-up (8/11 studies, 73%). Mobility decline was measured at a mean of 37 months from recruitment (range = 12–60 months).

Risk of Bias in Included Studies

Of the 61 included studies, the 58 etiological and predictor finding studies were appraised using Quality In Prognosis Studies (Supplementary Table S3 [available online]). Risk of bias varied across the studies: 11 studies (Avlund, Vass, & Hendriksen, 2003; Brenes et al., 2005; Guralnik et al., 1993; Ho, Woo, Yuen, Sham, & Chan, 1997; Jørgensen et al., 2017; Keskinen, Rantakokko, Suomi, Rantanen, & Portegijs, 2020; Mehta et al., 2007; Polku et al., 2015; Thorpe et al., 2011; Tsuji et al., 2018; Visser et al., 2005) (11/58, 19%) were rated as low risk of bias for all six domains and 30 studies (Abizanda et al., 2013; Auais et al., 2018, 2019; Avlund, Damsgaard, & Osler, 2004; Avlund et al., 1995, 2000, 2002; Ayis, Gooberman-Hill, Bowling, & Ebrahim, 2006; Carbone et al., 2013; Deshpande et al., 2014; Duan-Porter et al., 2019; Eggermont et al., 2014; Eronen, von Bonsdorff, Rantakokko, & Rantanen, 2013; Fried et al., 2000; Koster et al., 2005; LaCroix, Guralnik, Berkman, Wallace, & Satterfield, 1993; Lang, Llewellyn, Langa, Wallace, & Melzer, 2008; Leveille et al., 2001; Liljas et al., 2016; Mänty et al., 2007; Manty et al., 2009; Onder et al., 2003; Rantakokko, Iwarsson, Mänty, Leinonen, & Rantanen, 2012; Rantakokko, Portegijs, Viljanen, Iwarsson, & Rantanen, 2016; Schroll et al., 1997; Simonsick, Aronson, et al., 2018; Simonsick et al., 2016; Simonsick, Schrack, et al., 2018; Thakral et al., 2014; Weiss et al., 2012) (30/58, 52%) were rated as low risk of bias for five domains. Sources of bias most commonly related to study attrition, specifically lack of details provided regarding reasons for loss to follow-up or differences in key characteristics between those included and those lost to follow-up. Nine studies (Avlund et al., 2000; Ayis, Bowling, Gooberman-Hill, & Ebrahim, 2007; Ayis et al., 2006; Eronen et al., 2013; Manty et al., 2009; Onder et al., 2003; Rantakokko et al., 2012; van den Brink et al., 2004; Weiss et al., 2012) (9/58, 16%) were rated as high risk of bias for the study attrition domain, and 33 studies (Abizanda et al., 2013; An & Lu, 2016; Auais et al., 2018, 2019; Avlund, Damsgaard, & Osler, 2004; Avlund et al., 2002; Avlund, Lund, et al., 2004; Avlund, Pedersen, & Schroll, 2003; Carbone et al., 2013; Chen et al., 2012; Crimmins & Saito, 1993; Deshpande et al., 2014; Duan-Porter et al., 2019; Eggermont et al., 2014; Fried et al., 2000; Guralnik, Ferrucci, Balfour, Volpato, & Di Iorio, 2001; Koster et al., 2005; LaCroix et al., 1993; Lang et al., 2008; Lee et al., 2005; Leveille et al., 2001, 2007; Lindberg & Tilvis, 1998; Mänty et al., 2007; Nilsson et al., 2008, 2010; Pine, Gurland, & Chren, 2000, 2002; Rantakokko et al., 2016; Sauvaget, Tsuji, Aonuma, & Hisamichi, 1999; Simonsick, Schrack, et al., 2018; Thakral et al., 2014; Viljanen et al., 2012) (33/58, 57%) were rated as moderate risk of bias. Other major sources of bias related to statistical analysis and reporting, for which four studies (Crimmins & Saito, 1993; Pine et al., 2002; Simonsick, Aronson, et al., 2018; van den Brink et al., 2004) (4/58, 7%) were rated as high risk of bias, and 10 studies (Avlund, Damsgaard, & Osler, 2004; Avlund et al., 1995; Avlund, Lund, et al., 2004; Chen et al., 2012; Liljas et al., 2016; Lindberg & Tilvis, 1998; Pine et al., 2000; Sauvaget et al., 1999; Schroll et al., 1997; Viljanen et al., 2012) (10/58, 17%) were rated as moderate risk of bias.

The results of the Prediction model Risk of Bias Assessment tool appraisal for the model development studies are presented in Supplementary Table S4 (available online). All three studies (Chaves et al., 2000; Papachristou et al., 2017; Reynolds & Silverstein, 2003) were judged as having high risk of bias for the analysis domain. This was due to the absence of model performance measures, selection of predictor variables based on univariable analyses, and lack of reporting results of multivariable analyses. All three studies were judged to have both high risk of bias overall and high concern regarding applicability to the review question.

Risk Factors for Mobility Decline Identified in Etiological and Predictor Finding Studies

A synthesis of the self-reported risk factors for mobility decline examined in etiological and predictor finding studies is presented in Table 1 and Supplementary Table S5 (available online). Due to

Table 1 Overview of Risk Factors for Mobility Decline, Presented by Direction of Association, Using the Adapted GRADE (Huguet et al., 2013)

Risk factors	Number of participants[a]	Number of studies examining risk factor	Number of cohorts	Range of OR reported	Quality of evidence
Consistent evidence of increased risk of mobility decline[b]					
Older age	16,452	9 (Auais et al., 2018, 2019; Carbone et al., 2013; Crimmins & Saito, 1993; Deshpande et al., 2014; Guralnik et al., 1993, 2001; Ho et al., 1997; Sauvaget et al., 1999)	7	1.1–5.8 >75: 3.5–16.5	High
Mobility modification[c]	1,858	5 (Fried et al., 2000; Manty et al., 2009; Pine et al., 2002; Rantakokko et al., 2016; Weiss et al., 2012)	4	2.5–6.2 RR = 5.7–8.9	High
Widespread pain	1,102	3 (Eggermont et al., 2014; Leveille et al., 2001, 2007)	2	2.5–2.8 RR = 3.6	Moderate
Gender/sex (female/women)	14,528	8 (Auais et al., 2019; Ayis et al., 2007; Carbone et al., 2013; Crimmins & Saito, 1993; Deshpande et al., 2014; Guralnik et al., 2001; Sauvaget et al., 1999; Schroll et al., 1997)	8	1.2–2.6	High
Low annual income	10,047	2 (Guralnik et al., 1993; Koster et al., 2005)	2	1.3–2.6	Moderate
Low number of financial assets	6,533	5 (Deshpande et al., 2014; Jørgensen et al., 2017; Koster et al., 2005; Nilsson et al., 2010; Thorpe et al., 2011)	3	1.3–1.5	High
Low diversity in social relations	4,308	3 (Avlund, Lund, et al., 2004; Ho et al., 1997; Nilsson et al., 2010)	2	1.6–2.8	High
Low social engagement	3,292	4 (Avlund, Lund, et al., 2004; Ayis et al., 2006; Jørgensen et al., 2017; Nilsson et al., 2010)	2	1.5–2.9	High
Low physical activity	11,152	6 (Abizanda et al., 2013; Avlund et al., 2000; Carbone et al., 2013; LaCroix et al., 1993; Schroll et al., 1997; Visser et al., 2005)	5	1.5–4.3 RR = 4.3	High
Not walking each day	4,460	2 (Ho et al., 1997; Visser et al., 2005)	2	1.5–2.4	Moderate
Greater fatigue with exertion	1,514	3 (Abizanda et al., 2013; Simonsick et al., 2016; Simonsick, Schrack, et al., 2018)	2	1.1–1.5	Moderate
Greater tiredness in daily activities	1,975	5 (Avlund et al., 1995, 2002; Avlund, Pedersen, & Schroll, 2003; Simonsick et al., 2016; Simonsick, Schrack, et al., 2018)	2	1.5–10.8	Moderate
Hip pain	2,712	2 (Carbone et al., 2013; Eggermont et al., 2014)	2	1.5 RR = 4.5	Moderate
Knee pain	2,712	2 (Carbone et al., 2013; Eggermont et al., 2014)	2	2.0 RR = 2.7	Moderate
Fall/s in past year	802	2 (Carbone et al., 2013; Manty et al., 2009)	2	1.3–3.2	Moderate
Fear of falling	1,207	2 (Auais et al., 2018; Viljanen et al., 2012)	2	1.1–2.9	Moderate
Increasing no. health conditions	8,723	4 (Guralnik et al., 1993, 2001; Ho et al., 1997; Schroll et al., 1997)	3	1.4–3.4 RR = 1.3–5.3	High
Depression	4,818	4 (Ayis et al., 2006; Carbone et al., 2013; Deshpande et al., 2014; Ho et al., 1997)	4	1.1–6.5	High
Eye conditions	4,515	4 (Ayis et al., 2007; Carbone et al., 2013; Ho et al., 1997; Viljanen et al., 2012)	4	1.6–1.8	High
Heart conditions	3,537	2 (Crimmins & Saito, 1993; Ho et al., 1997)	2	1.4–1.7	High
History of stroke	10,518	4 (Crimmins & Saito, 1993; Guralnik et al., 1993, 2001; Ho et al., 1997)	3	1.4–2.7	Moderate
Sensory difficulties	2,344	2 (Crimmins & Saito, 1993; Viljanen et al., 2012)	2	1.3–2.5	Low
Poor self-rated health	7,537	4 (Avlund et al., 2000; Ayis et al., 2007; Guralnik et al., 2001; Ho et al., 1997)	4	1.3–3.3	High
Hospital stay in past year	4,963	2 (Crimmins & Saito, 1993; Duan-Porter et al., 2019)	2	1.1–1.3	Moderate

(continued)

Table 1 *(continued)*

Risk factors	Number of participants[a]	Number of studies examining risk factor	Number of cohorts	Range of OR reported	Quality of evidence
Consistent evidence of no association with mobility decline[b]					
Weight gain in past 12 months	4,415	2 (Ho et al., 1997; Lee et al., 2005)	2	0.9 HR = 0.88	Moderate
Cancer (previous or current)	7,213	3 (Ayis et al., 2007; Guralnik et al., 2001; Ho et al., 1997)	3	0.5–1.3	Moderate
Higher no. physical environment barriers	1,180	4 (Ayis et al., 2006; Eronen et al., 2013; Rantakokko et al., 2012, 2016)	3	0.9–1.5	Moderate
Limited evidence of increased risk of mobility decline[d]					
Housing tenure (renting)	386	1 (Avlund, Lund, et al., 2004)	1	1.9	Very low
High neighborhood deprivation	3,525	1 (Lang et al., 2008)	1	1.8	Very low
Not having health insurance	2,622	1 (Carbone et al., 2013)	1	1.3	Very low
Not driving a car	581	1 (Tsuji et al., 2018)	1	1.5	Very low
Living alone	2,825	5 (Avlund, Damsgaard, & Osler, 2004; Avlund et al., 1995; Jørgensen et al., 2017; Nilsson et al., 2008, 2010; Tsuji et al., 2018)	1	1.1–1.7	Very low
Widowhood	829	1 (van den Brink et al., 2004)	1	1.7–1.8	Very low
Currently not exercising	1,483	1 (Ho et al., 1997)	1	2.1	Very low
Low amount of exercise per day	1,483	1 (Ho et al., 1997)	1	2.2–3.4	Very low
Other functional difficulties	2,145	1 (Crimmins & Saito, 1993)	1	1.3–1.4	Very low
Low energy level	579	2 (Simonsick et al., 2016; Simonsick, Schrack, et al., 2018)	1	1.1–1.2	Very low
Low functional reserve capacity	427	1 (Ayis et al., 2006)	1	6.8	Very low
Increasing pain severity	411	1 (Eggermont et al., 2014)	1	2.0	Very low
Increasing pain interference	411	1 (Eggermont et al., 2014)	1	2.4	Very low
Back pain + other pain	412	1 (Eggermont et al., 2014)	1	3.3	Very low
Hip pain + other pain	412	1 (Eggermont et al., 2014)	1	4.8	Very low
Knee pain + other pain	413	1 (Eggermont et al., 2014)	1	3.3	Very low
Ankle/foot pain + other pain	412	1 (Eggermont et al., 2014)	1	3.7	Very low
Joint stiffness	524	1 (Thakral et al., 2014)	1	1.3–1.6	Very low
History of fracture	2,286	2 (Carbone et al., 2013; Ho et al., 1997)	1	1.1–1.6	Very low
Incontinence	5,263	1 (Guralnik et al., 2001)	1	1.1–1.2	Very low
Memory loss	1,483	1 (Ho et al., 1997)	1	1.4	Very low
Respiratory conditions	491	1 (Ayis et al., 2007)	1	1.3–3.5	Very low
Health deterioration in past year	427	1 (Ayis et al., 2006)	1	4.3	Very low
Major life changes in past 6 months	491	1 (Ayis et al., 2007)	1	1.5–2.3	Very low
Low sexual satisfaction	178	1 (Onder et al., 2003)	1	2.6	Very low

(continued)

Table 1 *(continued)*

Risk factors	Number of participants[a]	Number of studies examining risk factor	Number of cohorts	Range of OR reported	Quality of evidence
Weight change intention	2,907	1 (Lee et al., 2005)	1	HR: 1.6	Very low
Acetaminophen use	2,486	1 (Carbone et al., 2013)	1	1.6	Very low
Antidepressant use	4,242	1 (Carbone et al., 2013)	1	1.1	Very low
NSAID use	2,486	1 (Carbone et al., 2013)	1	1.4	Very low
Lack of resting places and long distances	266	1 (Rantakokko et al., 2012)	1	1.9–2.2	Very low
Limited evidence of no association with mobility decline[d]					
Weight change in past 12 months	2,932	1 (Lee et al., 2005)	1	HR = 0.8–1.49	Very low
Manual occupation	243	1 (Avlund et al., 2000)	1	1.1	Very low
Low satisfaction with living arrangement	1,483	1 (Ho et al., 1997)	1	1.4	Very low
Low instrumental support	156	1 (Avlund, Lund, et al., 2004)	1	2.8	Very low
Self-reported slowing	146	1 (Pine et al., 2000)	1	1.0	Very low
Changes in tiredness	136	1 (Avlund, Vass, & Hendriksen, 2003)	1	1.6	Very low
Hand/wrist pain	412	1 (Eggermont et al., 2014)	1	1.6	Very low
Hand/wrist pain + other pain	412	1 (Eggermont et al., 2014)	1	1.6	Very low
Lower limb joint pain	1,483	1 (Ho et al., 1997)	1	1.1	Very low
Ankle/foot pain	413	1 (Eggermont et al., 2014)	1	1.7	Very low
Injury caused by fall	1,483	1 (Ho et al., 1997)	1	1.3	Very low
Angina	6,981	2 (Guralnik et al., 1993, 2001)	1	1.0–1.6	Very low
Asthma	1,483	1 (Ho et al., 1997)	1	1.1	Very low
Bronchitis	1,483	1 (Ho et al., 1997)	1	1.4	Very low
Claudication	6,981	2 (Guralnik et al., 1993, 2001)	1	1.3–1.4	Very low
COPD	5,263	1 (Guralnik et al., 2001)	1	1.4–1.8	Very low
Dyspnea	6,981	2 (Guralnik et al., 1993, 2001)	1	1.2–1.5	Very low
Headache	1,483	1 (Ho et al., 1997)	1	1.3	Very low
History of heart attack	6,981	2 (Guralnik et al., 1993, 2001)	1	1.0–1.3	Very low
Lack of control over life	456	1 (Ayis et al., 2007)	1	1.0–1.9	Very low
Low satisfaction with life	1,483	1 (Ho et al., 1997)	1	1.2	Very low
Increased vulnerability to accidents	491	1 (Ayis et al., 2007)	1	1.3–2.0	Very low
Increased vulnerability to mugging, burglary	491	1 (Ayis et al., 2007)	1	0.8–1.9	Very low
Estrogen use	2,486	1 (Carbone et al., 2013)	1	0.8	Very low
Vitamin D use	2,486	1 (Carbone et al., 2013)	1	0.8	Very low
Distance to park or other green area	261	1 (Eronen et al., 2013)	1	2.3	Very low

(continued)

Table 1 *(continued)*

Risk factors	Number of participants[a]	Number of studies examining risk factor	Number of cohorts	Range of OR reported	Quality of evidence
Distance to outdoor recreational facilities	261	1 (Eronen et al., 2013)	1	1.7	Very low
Perceived hilliness in neighborhood	551	1 (Keskinen et al., 2020)	1	1.7	Very low
Hilly terrain and streets in poor condition	266	1 (Rantakokko et al., 2012)	1	1.1–1.4	Very low
Noisy traffic and dangerous crossroads	266	1 (Rantakokko et al., 2012)	1	1.3–1.5	Very low
Inconsistent/unclear association with mobility decline[e]					
Race (non-White)	4,784	3 (Carbone et al., 2013; Crimmins & Saito, 1993; Thorpe et al., 2011)	2	0.9–3.0	Very low
High alcohol consumption	8,464	2 (Ho et al., 1997; LaCroix et al., 1993)	2	1.0–1.2	Very low
Smoker/ex-smoker	8,707	4 (Avlund et al., 2000; Guralnik et al., 2001; Ho et al., 1997; LaCroix et al., 1993)	3	0.8–3.6	Very low
BMI outside of normal range	14,924	8 (Carbone et al., 2013; Crimmins & Saito, 1993; Deshpande et al., 2014; Guralnik et al., 2001; Ho et al., 1997; LaCroix et al., 1993; Lindberg & Tilvis, 1998; Tsuji et al., 2018)	7	0.8–2.1	Very low
Weight loss in past 12 months	5,350	3 (Abizanda et al., 2013; Ho et al., 1997; Lee et al., 2005)	3	1.0–1.6 HR = 0.8–2.0	Very low
Low level of education	12,996	11 (Avlund, Damsgaard, & Osler, 2004; Avlund et al., 1995, 2000; Ayis et al., 2007; Carbone et al., 2013; Deshpande et al., 2014; Guralnik et al., 1993, 2001; Ho et al., 1997; Koster et al., 2005; Thorpe et al., 2011)	6	0.9–2.3	Very low
Income from pension only	1,869	3 (Avlund, Damsgaard, & Osler, 2004; Avlund et al., 1995; Ho et al., 1997)	2	1.1–3.1	Very low
Low social status	2,789	2 (Avlund et al., 1995; Chen et al., 2012)	2	1.0–1.5	Very low
Low social support	6,082	5 (Avlund, Lund, et al., 2004; Ayis et al., 2006; Carbone et al., 2013; Deshpande et al., 2014; Jørgensen et al., 2017)	4	0.9–2.3	Very low
Higher no. musculoskeletal conditions	734	2 (Avlund et al., 2000; Ayis et al., 2007)	2	1.8–2.8	Very low
Back pain	1,077	2 (Eggermont et al., 2014; Simonsick, Aronson, et al., 2018)	2	1.0–1.7	Very low
Hip fracture	7,408	2 (Crimmins & Saito, 1993; Guralnik et al., 2001)	2	1.0–3.2	Very low
Anxiety	4,209	3 (Ayis et al., 2006; Brenes et al., 2005; Mehta et al., 2007)	3	1.0–1.2 HR = 1.3	Very low
Arthritis	10,609	4 (Crimmins & Saito, 1993; Guralnik et al., 1993, 2001; Ho et al., 1997)	3	1.1–1.4	Very low
Circulatory conditions	491	1 (Ayis et al., 2007)	1	1.7	Very low
Cognitive decline	6,376	3 (Ayis et al., 2007; Deshpande et al., 2014; Guralnik et al., 2001)	3	1.0–2.5	Very low
Diabetes	8,464	3 (Guralnik et al., 1993, 2001; Ho et al., 1997)	2	1.3–2.3	Very low
Dizziness/balance difficulties	1,773	2 (Ho et al., 1997; Viljanen et al., 2012)	2	1.0–1.4	Very low
Hearing problems	5,837	6 (Ayis et al., 2006, 2007; Ho et al., 1997; Liljas et al., 2016; Polku et al., 2015; Viljanen et al., 2012)	5	1.1–2.8	Very low
High blood pressure	10,609	3 (Crimmins & Saito, 1993; Guralnik et al., 1993; Ho et al., 1997)	3	1.1–1.2	Very low

Note. OR of 1.4–2.5 = small effect; 2.5–4.25 = moderate effect; ≥4.25 = large effect. The range shown is the lowest and highest OR reported by included studies. RR = risk ratio; HR = hazard ratio; GRADE = Grading of Recommendations Assessment, Development and Evaluation; OR = odds ratio; BMI = body mass index; NSAID = nonsteroidal anti-inflammatory drug; COPD = chronic obstructive pulmonary disease.

[a]When more than one study examining the same factor was derived from the same cohort, the highest number of participants was added to the participant total. [b]Two or more studies from two or more cohorts; >75% of studies showing the same direction of effect. [c]Mobility modifications defined as any of resting during the task, using an aid, using handrails, reduced frequency, or reduced speed of performing the task. [d]Single study or multiple studies from single cohort. [e]Two or more studies from two or more cohorts; <75% of studies showing the same direction of effect, or single study with insufficient data to assess association.

variation in methods of measurement for risk factors and/or mobility outcomes, we were unable to formally pool the results using meta-analysis (Riley et al., 2019).

Of the 107 risk factors examined in these studies, there was consistent evidence (less than or equal to two studies from less than or equal to two cohorts) that 24 factors were associated with mobility decline. Of these 24, three were associated with a moderate/large effect and 21 associated with a small effect. There was also consistent evidence of no association with mobility decline for three factors. The results and discussion will focus on these 27 factors.

Among the remaining 80 risk factors, there was limited evidence (single study or multiple studies from a single cohort) of association with mobility decline for 30, limited evidence of no effect on mobility decline for 30, and inconsistent or unclear effects on mobility decline for 20 factors (Table 1 and Supplementary Table S5 [available online]).

Factors with consistent moderate/large effect on mobility decline. Three factors were consistently associated with mobility decline with moderate–large effect sizes. There was high quality evidence for older age, with large effect sizes reported for participants aged 75 years or older compared to those younger than 75 years. There was also high quality evidence and a dose–response effect observed for mobility modifications (resting during the task, using an aid, using handrails, reduced frequency or reduced speed of performing the task). Moderate quality evidence was found for the presence of widespread pain as a risk factor for mobility decline.

Factors with consistent small effect on mobility decline. For the remaining 21 risk factors consistently associated with mobility decline, the strength of the association represented by ORs was considered small (Table 1). There was high-quality evidence for five demographic and socioeconomic risk factors. Female gender was associated with increased risk of mobility decline, as was low annual income; low number of financial assets; low diversity in social relations; and low social engagement.

Five risk factors were associated with physical- and fatigue-related issues. Low physical activity was associated with mobility decline with high quality evidence. There was moderate quality evidence for not walking every day, having at least one fall in the past year, higher fatigue after exertion, and greater tiredness in daily activities as risk factors for mobility decline.

Evidence for the consistent small effect of 10 health factors on mobility decline ranged from high to low quality. High quality evidence was found for increasing number of health conditions. Specific health conditions presenting as risk factors for mobility decline included depression (high quality evidence), eye conditions (high quality evidence), heart conditions (high quality evidence), history of stroke (moderate quality evidence), and sensory difficulties (low quality evidence). Other factors that showed a consistent small association with increased risk of mobility decline were hip pain (moderate quality evidence), knee pain (moderate quality evidence), poor self-rated health (high quality evidence), and reporting a hospital stay in the past year (Table 1 and Supplementary Table S5 [available online]).

Factors with consistent lack of effect on mobility decline. Moderate quality evidence was found for three factors which consistently demonstrated no association with increased risk of mobility decline: weight gain in the past 12 months, history of or current cancer diagnosis, and reporting a higher number of physical environment barriers (e.g., long distances, busy traffic, rough or hilly terrain, high crime area; Table 1 and Supplementary Table S5 [available online]).

Model Development Studies

The three model development studies are summarized in Table 2 and Supplementary Table S2 (available online). Follow-up periods

Table 2 Synthesis of Risk Factors for Mobility Decline Examined in Included Model Development Studies

Study	Outcome	Risk factor/s included in final model	Study sample size *n* (% of participants with the outcome)	Type of validation	Performance
Chaves et al. (2000)	Onset of mobility difficulty. Difficulty in at least one of the tasks: walking 0.8 km; climbing 10 steps; transferring from/into a car or bus	Task modification + walking time for 1 m at usual pace + one-leg stance balance	266 (23.9)	Bootstrap validation	Apparent performance ONLY • AUC = 0.73 • Classification and discrimination measures (correct classification[a]) were presented using multiple predicted probability thresholds
Papachristou et al. (2017)	Incident disability. Difficulty in at least one of the tasks: walking 400 yards; going up or down stairs	Age + slow walking speed + physical inactive + exhaustion	NR (15.0)	Not reported	• AUC = 0.68 (0.63–0.72)
Reynolds and Silverstein (2003)	Onset of walking disability	41 variables including demographic, medical, and behavioral characteristics[b]	3,964 (10.7)	Not reported	Apparent performance ONLY: • AUC = 0.819 • Hosmer–Lemeshow test = 14.47, $p = .07$ • Adjusted $R^2 = .1817$

Note. Apparent performance is the performance observed in the development data. AUC = area under the curve; IADL = instrumental activities of daily living; NR = not reported.

[a]Percentage of individuals whose predicted and observed probabilities are the same. [b]Age, sex, hypertension, diabetes, cancer, lung disease, heart condition, psychiatric problems, arthritis, stroke, married, ethnicity (Hispanic and Black), family network, asset complexity, negative affect, cognition, home modification, weight, impairment, smoke, service use, health insurance, onset of hypertension, onset of diabetes, onset of cancer, onset of lung disease, onset of heart condition, onset of psychiatric problems, onset of arthritis, onset of stroke, deterioration in affect, deterioration in cognition, new home modifications, weight loss, onset of Nagi impairments, onset of IADL impairments, smoking less, new service use, vigorous exercise, and preventive test.

varied from recruitment: 18 months (Chaves et al., 2000); 36 months (Papachristou et al., 2017); and 60 months (Reynolds & Silverstein, 2003). Overall, the three models showed a moderate discriminative ability (area under curve [AUC] = 0.68–0.81), but calibration measures were poorly reported or missing. Only one model was internally validated (Chaves et al., 2000) and none undertook external model validation.

Discussion

This systematic review provides evidence on self-reported factors which predict decline in self-reported mobility between 12 months and 5 years in older adults. Among the 107 risk factors examined in the included studies, we found that 24 had consistent moderate or high quality evidence indicating their association with mobility decline. Effect sizes were generally small, with moderate/large effect sizes observed for three factors: older age (≥75 years), widespread pain, and mobility modifications. Three existing model development studies were identified, all demonstrating moderate model discriminatory performance, and limited by high risk of bias because of analytical shortcomings.

To our knowledge, this is the first systematic review to comprehensively summarize available evidence about self-reported risk factors for self-reported mobility decline among older adults. Among the 107 risk factors we reviewed, only one quarter had sufficient evidence from which to draw firm conclusions regarding association with mobility decline. This does not mean that the remaining factors do not play a role in mobility decline in later life, rather that evidence was insufficient to draw such a conclusion. Significant heterogeneity across studies in definitions and assessments of risk factors and mobility decline precluded quantitative synthesis of the data, and consequently our findings must be interpreted with caution.

A 2008 narrative review concluded that the association between older age and increased mobility limitations was statistically significant over 70 years of age (Yeom et al., 2008). Age-related changes in mobility may result from physiological changes, such as decreased muscle strength and power, reduced bone mass, and decreased response to balance perturbations (Byrne, Faure, Keene, & Lamb, 2016). However, age-related changes in mobility may also be associated with, or accelerated by, lack of physical activity, leading to a negative cycle of decline (Brach et al., 2003).

The negative effects of widespread pain on physical functions, including mobility, are well established (Butera, Roff, Buford, & Cruz-Almeida, 2019). However, the pathway from widespread pain to mobility limitation is not clear. Nagi's disablement model suggests that widespread pain may lead to decreased physical activity, and in turn loss of muscle strength and the development of mobility limitations (Verbrugge & Jette, 1994). However, Leveille et al. concluded that pain is a unique domain as a cause of mobility difficulty, independent of the usual pathway via physical impairments (Leveille et al., 2007).

Mobility modifications, such as resting, using an aid, using handrails, reduced frequency, or speed of performing a task are important risk factors among older adults as they have been identified as "preclinical mobility decline" (Fried et al., 2000; Rantakokko et al., 2013). Making such modifications may compensate for the impact of underlying health changes, such as pain, reduced muscle strength, or fatigue on mobility (Fried et al., 2000). An individual's transition to mobility difficulty easily occurs when any internal or external changes overwhelm the compensations being employed. Our findings reiterate the importance of assessing the use of mobility modifications to identify people at high risk of mobility decline so the underlying causes can be addressed.

This review identifies several opportunities for targeting modifiable factors associated with mobility decline, which should be considered in management of older adults at risk of mobility decline, and intervention development. We found high quality evidence of the association between two social factors (low diversity in social relations and low social engagement) and increased risk of mobility decline. This highlights the importance of assessing social outcomes, which are often neglected, and the potential of social prescribing interventions. We also found high quality evidence for low physical activity as a risk factor for mobility decline. Many physical activity programs have been used to improve mobility in older adults, with positive effects (Rantakokko et al., 2013). Assessing and addressing fears of falling in older adults is also important, as indicated by our finding of moderate quality evidence for fear of falling as a risk factor for mobility decline.

Our findings highlight the complexity of managing older adults at risk of mobility decline. Mobility decline in older age is multifactorial, and many older adults may report multiple risk factors concurrently. Combinations of multiple risk factors may have greater impact than the sum of their individual effects, and future research should explore this. Future interventions targeting maintenance of mobility should be multidimensional, combine interventions for multiple risk factors, and control for confounding factors. Our findings also highlight the limited evidence for existing prognostic models for mobility decline. These results may guide future longitudinal studies to develop a prediction instrument for practical application.

Limitations of the Review

Despite the authors' effort to construct a sensitive search strategy, there is a chance that relevant studies were overlooked. Of the included studies, 70% (43/61) came from two countries (United States and Finland), which may impact the generalizability of findings to other populations. Only 3% of studies (2/61) included participants from low-income countries (World Bank, 2020). None of the included studies were conducted in Africa, and only two were conducted in Asia (Hong Kong and Japan). Differing lifestyles and cultures may mean that risk factors are not the same in these settings, and findings should not be generalized. Studies in more diverse international settings are warranted. Grouping together everyone with mobility decline may dilute associations linked with specific subtypes of mobility decline, such as gradual versus rapid decline. Analysis of risk factors according to definitions of mobility decline may give more insight into causal pathways. Almost all included studies (59/61, 97%) used narrow measures of mobility, focusing on ability to walk and/or climb stairs. Use of broader measures of mobility, such as life–space assessment may enable identification of additional risk factors, and/or which risk factors are associated with different aspects of mobility. Finally, by excluding studies with follow-up periods of <12 months or >5 years, there is a risk that studies showing short- or long-term results were missed.

Conclusion

In conclusion, our systematic review identified 24 wide-ranging self-reported risk factors consistently associated with self-reported mobility decline in older people. Older age beyond 75 years, the presence of widespread pain, and mobility modifications were the risk factors with the highest effect.

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