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REVIEW ARTICLE

Pre-discharge prognostic factors of physical function among older adults with hip fracture surgery: a systematic review

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Abstract

Introduction To identify, organize, and assess the evidence level of pre-discharge prognostic factors of physical function beyond discharge after hip fracture surgery.

Methods We performed a systematic search of four databases (PubMed, Embase, CINAHL, PsycINFO) for longitudinal studies of prognostic factors of physical function at ≥ 1 month among older adults ≥ 50 years old with surgically treated hip fracture, complemented with hand-searching. Two reviewers independently screened papers for inclusion and assessed the quality of all the included papers using the Quality in Prognosis Studies (QUIPS) tool. We assigned the evidence level for each prognostic factor based on consistency in findings and study quality.

Results From 98 papers that met our inclusion criteria, we identified 107 pre-discharge prognostic factors and organized them into the following seven categories: demographic, physical, cognitive, psychosocial, socioeconomic, injury-related, and process of care. Potentially modifiable factors with strong or moderate evidence of an association included total length of stay, physical function at discharge, and grip strength. Factors with strong or moderate evidence of no association included gender, fracture type, and time to surgery. Factors with limited, conflicting, or inconclusive evidence included body-mass index, psychological resilience, depression, and anxiety.

Conclusions Our findings highlight potentially modifiable prognostic factors that could be targeted and non-modifiable prognostic factors that could be used to identify patients who may benefit from more intensive intervention or to advise patients on their expectations on recovery. Examining the efficacies of existing interventions targeting these prognostic factors would inform future studies and whether any of such interventions could be incorporated into clinical practice.

Keywords Elderly · Hip fracture · Older adults · Physical function · Prognostic factors · Systematic review

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Introduction

Hip fracture is a growing public health concern in the face of an aging population worldwide [1, 2]. Despite accounting for only a fraction of total fractures affecting the older adults, it consumes a disproportionate amount of healthcare resources [3, 4].

Clinical guidelines emphasize multi-disciplinary management of patients with hip fracture. Patients should ideally undergo surgical treatment as early as possible after admission to the hospital to minimize mortality risk [5, 6]. Thereafter, inpatient management of hip fracture focuses on preventing surgical complications, allowing patients to mobilize early and returning patients to pre-fracture residence [7]. Interventions to improve physical function, mostly rehabilitation programs that vary in types, intensity, and duration of exercises [8–11], may be initiated during inpatient stay and extend beyond discharge. However, to date, there is no consensus on the best intervention to enhance physical function after hip fracture surgery [12] and the best timing for such intervention [7].

Optimizing care for rapid and complete recovery requires an understanding of the relationship between prognostic factors and recovery. In particular, recovery of physical function beyond discharge is the most salient for patients and their caregivers [13] as the loss of physical function due to hip fracture may take beyond a year to recover [14–16]. Existing systematic reviews have examined prognostic factors of mortality [17–20] and physical function at discharge [21]. While many studies have investigated the association between prognostic factors and physical function post-discharge, there has not yet been a systematic examination of such prognostic factors. A comprehensive understanding of pre-discharge prognostic factors of physical function beyond discharge would not only allow the care providers to act on potentially modifiable prognostic factors but also to better customize post-discharge plan and to advise patients on their physical function prognosis.

Therefore, our present study aimed to identify, to organize, and to assess the evidence level of pre-discharge prognostic factors associated with physical function beyond discharge among older adults with hip fracture surgery.

Methods

Search strategy

The protocol for our systematic review was prospectively registered on the International Prospective Register of Systematic Reviews (PROPSERO ID: CRD42017054196) [22].

We performed systematic search in four bibliographic databases (PubMed, Embase, CINAHL Plus, PsycINFO) from inception of the respective databases until 7th May 2017. In addition to peer-reviewed articles, CINAHL Plus also indexed dissertations. We developed the search strategy (see Appendix 1) based on previous systematic reviews on similar topic [18, 19, 23] to cover the following five concepts: hip fracture, surgical treatment, prognostic factor, physical function or mortality, and longitudinal study. We also consulted a librarian who worked in the medical library of our university to refine the search terms. Our search strategy included "mortality" as we had initially intended to update past systematic reviews on prognostic factors of mortality. However, as there is a recent publication [20] on the same topic, our present study focuses only on prognostic factors of physical function among survivors.

To identify gray literature and additional articles that may have been missed in the database search, we screened the reference lists of eligible articles as well as opinion articles and literature reviews before exclusion. We also performed searches on Google Scholar.

Study selection

We de-duplicated the citations on EndNote before importing them into Covidence for screening. Two researchers (KKL and JLC) independently screened the titles and abstracts for potential eligibility. Subsequently, the same researchers screened the full texts of potentially eligible articles. Both researchers resolved conflicts via consensus, failing which they consulted a third researcher (DBM).

Inclusion and exclusion criteria

We included articles that examined the association between a pre-discharge prognostic factor (i.e., prognostic factors identified before discharge from acute care) and any measure of physical function outcome at ≥ 1-month follow-up. We defined "physical function" as "the execution of a task or action by an individual," in accordance with the International Classification of Functioning, Disability, and Health (ICF) definition of "activity" [24]. We chose 1 month ("short-term") as the cut-off because little recovery occurs within the first month after hip fracture [15]. This also reduces the heterogeneity in the index time of follow-up (which was defined as admission, surgery, discharge, or not specified clearly) for narrative synthesis. All patients must be ≥ 50 years old (according to the individual studies' eligibility criteria) who experienced hip fracture due to low-impact trauma, followed from acute hospital admission (inception cohort), and surgically treated. We used 50 years as the cut-off, as it is the conventional age threshold for reporting the incidence and prevalence of hip fracture [2]. As psychometric tools are commonly used in hip fracture literature [25, 26], we also included studies that used psychometric tools to measure "physical function" as long as they contained items corresponding to execution of a task or an action. We included peer-reviewed articles and gray literature written in English.

We excluded studies that examined peri-prosthetic fractures. We also excluded studies that performed only univariate analyses to minimize unobserved confounding in the associations. We also excluded conference abstracts, case studies, opinion articles, and literature reviews.

Data extraction

From eligible studies, one researcher (KKL) extracted study characteristics, baseline sample characteristics, measures and operationalization of physical function and prognostic factors, type of analyses, effect sizes, 95% confidence intervals (95% CI), and *p* values. Another researcher (JLC) checked the data for accuracy.

Wherever possible, we differentiated the prognostic factors by their definitions. For example, for the factor "length of stay" (LOS), we separately considered total LOS, LOS before surgery, LOS after surgery, and LOS unspecified. Likewise, when available, we extracted specific co-morbidities or post-operative complications and distinguished them from validated indices (e.g., Charlson's index) and count (e.g., number of co-morbidities from a list of 11 conditions selected by the researchers [27]).

For studies that presented multiple models, we extracted pre-discharge prognostic factors from the final model as conceptualized by the authors. For studies that performed analyses for overall study samples and subsets, we extracted prognostic factors for the overall study samples. For studies that reported multiple physical function outcomes, we extracted all outcomes along with prognostic factors examined against them.

Quality assessment

Two researchers (KKL and JLC) independently assessed the methodological quality of eligible articles using the Quality in Prognostic Study (QUIPS) tool [28, 29]. The tool is comprised of the following six domains: participation, attrition, prognostic factor measurement, outcome measurement, confounding, and statistical analysis and reporting. Each domain was rated low, moderate, or high risk of bias based on 3–6 prompt items [29], by referring to relevant sections of the article including the reported limitations. To assess statistical analysis, we also considered pre-fracture physical function and age as important potential confounders which should be accounted for either in the study design or statistical analysis, unless the authors provided justifications that these variables were not potential confounders for their samples. Both researches resolved their disagreements via consensus, failing which they consulted a third researcher (DBM). In the baseline analyses, we considered a study as "good quality" if all six domains in QUIPS have low or moderate risk of bias or as "poor quality" otherwise [29]. To explore the impact of a more stringent quality criteria [28], we performed a sensitivity analysis in which we required a study to have low risk of bias in all domains to be considered "good quality."

Statistical analyses

We included pre-discharge prognostic factors for all physical function outcomes in the analyses. As most recovery happens within the first six months after hip fracture [14, 15], we considered outcome ≥ 1–6 months as "medium-term" and $>$ 6 months as "long-term." We organized the prognostic factors into the following seven categories: physical, cognitive, demographic, socio-economic, psychosocial, injury, and process of care; the first five categories were based on the Framework for Mobility in Older Adults [30].

The diverse measures and operationalizations of physical function and prognostic factors prohibited meta-analysis of the effect sizes. Therefore, we performed a narrative synthesis by stratifying the evidence levels for each prognostic factor into strong, moderate, limited, inconclusive, and conflicting based on study quality and consistency across $\geq 75\%$ findings [31]. Specifically, a prognostic factor had strong evidence if it had been examined ≥ 2 times in good-quality studies, of which $\geq 75\%$ produced consistent findings. A prognostic factor had moderate evidence if it had been examined once in a good-quality study with consistent findings in ≥ 2 times in poor-quality studies. Meanwhile, a prognostic factor had limited evidence if it had only been examined once in good- and poor-quality study each or produced consistent findings ≥ 3 times in poor-quality studies alone. The evidence for a prognostic factor was inconclusive if it had only been examined $<$ 3 times in poor-quality studies. Regardless of the study quality, the evidence was conflicting if there were consistent findings in $< 75\%$ of the time. The algorithm (see Appendix 2 for graphical presentation) has been used in similar studies when meta-analyses were not possible [32, 33]. For prognostic factors that were continuous, ordinal, or binary (yes/no), consistency accounted for the same direction of association (positive, negative, none) as well as statistical significance ($p < 0.05$) whereas for prognostic factors that were nominal (fracture side, fracture type, place of injury), consistency accounted for statistical significance.

We presented prognostic factors with strong or moderate evidence according to time periods and their potential modifiability. We performed data cleaning and analyses using R x64 3.4.4 (The R Foundation for Statistical Computing, Vienna).

Results

We reported our systematic review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (Appendix 3).

Study inclusion

Our search strategy identified 13,186 articles, out of which 9157 were unique. We removed 8816 articles from title and abstract screens and a further 259 articles from full-text screens. The three main reasons for exclusion from full-text screens were as follows: did not examine pre-discharge prognostic factors ($n = 48$), only performed univariate analyses ($n = 43$), and examined outcome < 1 month ($n = 41$). The total number of articles for extraction was 98, including 16 articles from reference lists and Google Scholar (Fig. 1). We also screened the reference list of the three opinion articles and literature reviews and did not identify any additional relevant articles.

Study and baseline sample characteristics

Out of the 98 articles, most were prospective cohort studies (84.7%); almost half were published between 2010 and 2017 (49.0%) and conducted in the United States (43.9%). All were peer-reviewed articles, except two that were graduate student dissertations [34, 35]. Sample size at baseline ranged from 33 to 25,649 with a median of 78% females and a median age between 80 and 85 years. Most articles (73.5%) examined medium-term physical function (≥ 1–6 months), with each article reporting a median of 1.5 physical function outcomes and a median of 8 prognostic factors (see Appendix 4 for the descriptive table).

Quality assessment

In the baseline quality assessment, 50% had good quality. However, using more stringent criteria in a sensitivity analysis, the proportion was reduced to 6.1% (see Appendix 5 for the full list of articles and quality ratings). The small number of articles having "good quality" in sensitivity analyses was due to many studies having moderate risk of bias in at least one domain.

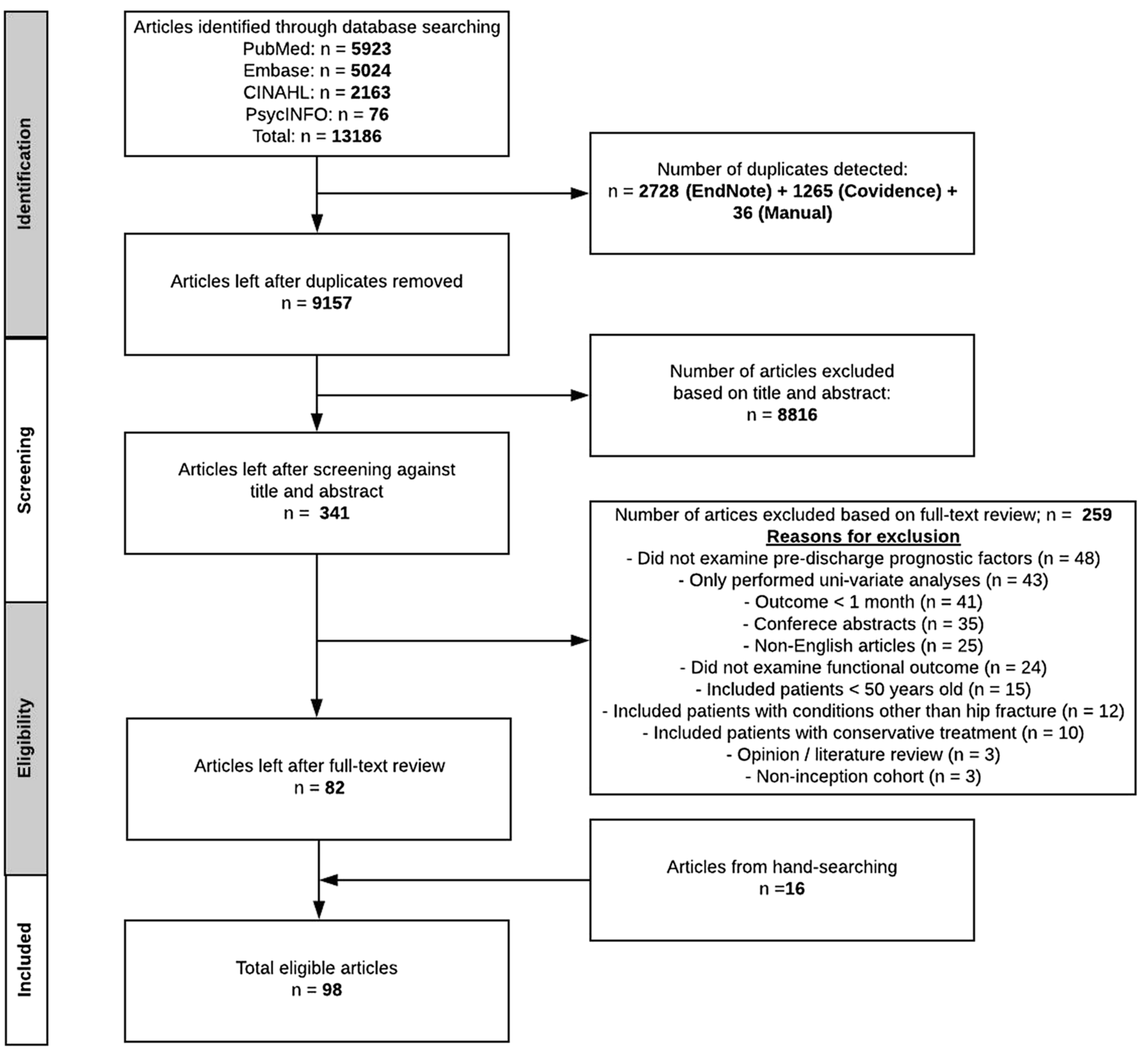

Fig. 1 Study screening and selection flow chart

The main quality domain contributing to "poor quality" was attrition (43.9% of the articles rated high risk of bias in this domain). While all studies reported the number of samples lost to follow-up, only a small minority of the articles described the reasons for drop-out (25.5%), described the characteristics of those who dropped out (14.2%), described attempts to collect information from drop-outs (13.3%), or demonstrated no important differences between participants who did and did not drop out (8.2%).

Less common reasons studies were designated "poor quality" were related to statistical analysis and reporting (12.2% high risk of bias), confounding (6.1% high risk of bias), outcome measurement (6.1% high risk of bias), prognostic factor measurement (3.1% high risk of bias), and participation (1.0% high risk of bias). On statistical analysis and reporting, we rated 67 (68.4%) as having sufficient presentation of data to assess the adequacy of analytical strategy. On confounding, while most studies measured (87.8%) and provided clear definition of their confounders (94.9%), only 55 (56.1%) accounted for important potential confounders, such as pre-fracture function in the study design or analysis. While most studies (76.5%) examined mortality as a separate outcome or reported missing data due to mortality, all studies included only survivors or individuals who were contactable for follow-up without accounting for competing risk of death in the analyses.

Categories of prognostic factors

We identified 107 prognostic factors; physical factors such as biomarkers, co-morbidities, and post-operative complications were the most common (58.9%). This was followed by factors related to process of care (15.0%) such as availability of inpatient rehabilitation; psychosocial factors (13.1%) such as depression; demographic factors (3.7%) such as gender; injury-related factors (3.7%) such as fracture type; cognitive factors (2.8%) such as dementia; and socio-economic factors (2.8%) such as income.

These 107 prognostic factors have been examined 1174 times, accounting for the number of studies and the number of outcomes in each study. Physical factors were the most frequently examined (45.0%), followed by demographic factor (20.3%), cognitive factors (13.9%), process of care (8.3%), psychosocial factors (5.7%), injury-related factors (4.7%), and socio-economic factors (2.1%).

More prognostic factors have been examined against medium- than against long-term physical function (Table 1). However, only a small number of prognostic factors had strong or moderate evidence (27/82 and 19/65 for medium- and long-term outcomes in baseline analyses), elaborated in subsequent texts. Prognostic factors with limited, conflicting, or inconclusive evidence included body-mass index, psychological resilience, depression, and anxiety (see Appendix 6 for the full list).

Potentially modifiable prognostic factors with strong or moderate evidence

A higher number of reported potentially modifiable prognostic factors had an association with physical function than did not (Table 2). In the baseline analyses, 8 potentially modifiable prognostic factors—early weight bearing or early rehabilitation, grip strength, total LOS, nutritional status, post-operative pain, post-operative complication count, self-efficacy, and vitamin D level—had strong or moderate evidence of association with medium-term physical function. Two prognostic factors—early weight bearing or early rehabilitation and physical function at discharge—had strong or moderate evidence of an association with long-term physical function. In contrast, bone mineral density, having spouse or child as confidant, hemoglobin level, and social network had strong or moderate evidence of no association with medium-term physical function. Time to surgery was the only potentially modifiable prognostic factor having strong or moderate evidence of no association with long-term physical function.

Non-modifiable prognostic factors with strong or moderate evidence

Factors that are non-modifiable once a fracture occurs outnumbered potentially modifiable ones in both medium- and long-term (Table 2). In the baseline analyses, 5 non-modifiable prognostic factors—Parkinson's disease, fall history, pre-fracture physical function, required caregiver assistance pre-fracture, and living in care home pre-fracture—had strong or moderate evidence of an association with medium-term physical function. Meanwhile, cognitive factors (namely cognitive impairment, delirium, dementia) and living in own home pre-fracture had strong or moderate evidence of an association with long-term physical function. Demographic factors (gender, marital status), several specific co-morbidities (diabetes, respiratory disease), co-morbidity indices (Charlson's index, RAND index), and living alone or with spouse pre-fracture were among the non-modifiable prognostic factors with no association with physical function.

Sensitivity analyses

In sensitivity analyses, 7 potentially modifiable and 11 non-modifiable prognostic factors retained strong or moderate evidence (see Appendix 7 for the full list). Meanwhile, the evidence level of 3 other factors (depression, social support, age) improved. All factors with strong or moderate evidence in sensitivity analyses had similar direction of association in the baseline analyses, except co-morbidity count. This was

Table 1 Number of prognostic factors at each evidence level according to time periods in baseline and sensitivity analyses

Evidence level	Medium-term physical function (≥ 1–6 months)		Long-term physical function (> 6 months)	
	Total	Association: yes/no	Total	Association: yes/no
Baseline analyses				
Strong	27[a]	13/14	16[b]	5/11
Moderate	0	0/0	3[c]	1/2
Limited	17	9/8	21	0/21
Conflicting	24	–	17	–
Inconclusive	14	–	8	–
Total	82	–	65	–
Sensitivity analyses				
Strong	6	4/2	6	3/3
Moderate	2	1/1	5	0/5
Limited	20	7/13	23	3/20
Conflicting	25	–	18	–
Inconclusive	29	–	13	–
Total	82	–	65	–

[a] Twenty two out of 27 factors did not retain strong/moderate strength of evidence in sensitivity analysis for medium-term physical function

[b] Eight factors out of 16 did not retain strong/moderate strength of evidence in sensitivity analysis for long-term physical function

[c] One out of 3 factors did not retain strong/moderate strength of evidence in sensitivity analysis for long-term physical function

due to a single study [36] with low risk of bias in all six QUIPS domains, which reported that higher number of co-morbidities had a negative association with physical function, in contrast to most other studies in the baseline analyses which found no association. The study [36] did not report the list of co-morbidities used to generate the co-morbidity count.

Discussion

In this systematic review, we identified, organized, and assessed the evidence level of 107 pre-discharge prognostic factors of physical function beyond discharge among older adults ≥ 50 years old. To the best of our knowledge, this is the first systematic review on pre-discharge prognostic factors of physical functions beyond discharge, as current literature has focused only on mortality [17, 18] and physical function at discharge [21]. We also contribute to the literature by reporting the gaps in evidence as well as gaps in study quality in examining the association between pre-discharge prognostic factors and physical function beyond discharge.

Several prognostic factors identified by our study, such as early weight bearing or early rehabilitation after hip fracture surgery, management of postoperative pain, and nutritional status, are potentially modifiable and are within the recommendations of current clinical guidelines [7, 37]. Prognostic factors that are potentially modifiable but are not within current clinical guidelines for hip fracture are grip strength, self-efficacy, and social support. There are ongoing trials on older adults [38] and those with hip fracture [39] that aim to intervene on these factors. Hence, it may be worthwhile for researchers to consider systematic reviews of their efficacies in improving physical function to inform future interventional studies.

Our study found strong or moderate evidence of no association between co-morbidity indices (Charlson's and RAND) and physical function post-discharge. This may reflect the fact that these indices were developed to predict mortality [40, 41] rather than physical function. While there is an existing co-morbidity index developed to predict physical function [42], experts opined that the list of co-morbidities in the index should be modified for patients with hip fracture [43]. Unfortunately, we were unable to identify specific lists of co-morbidities associated with physical function for patients with hip fracture, due to varying lists of co-morbidities in the included studies. For instance, Kondo et al. [44] used a list of 38 co-morbidities whereas Tseng et al. [27] used a list of 11 co-morbidities. There were also studies that did not explicitly list the co-morbidities they used [36]. Future studies may develop a co-morbidity index to predict physical function among patients with hip fracture.

Out of the 18 specific co-morbidities and cognitive factors that have been examined (Appendices 6–7), only Parkinson's disease, cognitive impairment, dementia, and delirium had strong or moderate evidence of an association with physical

Table 2 Prognostic factors with strong or moderate evidence (with and without association) according to time periods (medium- vs long-term) and potential modifiability (potentially modifiable and non-modifiable) in baseline analyses and sensitivity analyses

Period	Association	Modifiability	Prognostic factors	BA	SA
Medium	Yes	Potentially modifiable	Physical		
			• Grip strength	/	
			• Nutritional status	/	
			• Post-operative pain	/	
			• Vitamin D level	/[a]	
			• Post-operative complication count	/	
			Psychosocial		
			• Depression		/[a]
			• Self-efficacy	/[a]	
			• Social support		/[a]
			Process of care		
			• Early weight bearing/rehab	/	
			• Total length of stay	/	/
Medium	Yes	Non-modifiable	Physical		
			• Co-morbidity—Parkinson's	/[a]	
			• Co-morbidity count[b]		/[a]
			• Fall history	/[a]	
			• Pre-fracture function	/	
			Psychosocial		
			• Required caregiver assistance pre-fracture	/[a]	
			• Living in care home pre-fracture	/	/
Medium	No	Potentially modifiable	Physical		
			• Bone mineral density	/[a]	
			• Hemoglobin level	/	
			Psychosocial		
			• Confidant—spouse or child	/	/
			• Social network	/	/[a]
Medium	No	Non-modifiable	Physical		
			• Abnormal clinical findings—any	/	
			• Co-morbidity—cardiovascular diseases	/[a]	
			• Co-morbidity—stroke	/[a]	
			• Co-morbidity count[b]	/	
			• Charlson's comorbidity index	/	
			• RAND comorbidity index	/	
			Demographic		
			• Gender	/	/
			Marital status	/	
			Injury-related		
			• Fracture type	/	
			Psychosocial		
			• Pre-fracture living with spouse	/[a]	
Long	Yes	Potentially modifiable	Physical		
			• Physical function at discharge	/	/
			Process of care		
			• Early weight bearing/rehab	/	
Long	Yes	Non-modifiable	Cognitive factors		
			• Cognitive impairment	/	/
			• Delirium	/	

Table 2 (continued)

Period	Association	Modifiability	Prognostic factors	BA	SA
			• Dementia	/	
			Demographic		
			• Age		/
			Psychosocial		
			• Pre-fracture living in own home	/	
Long	No	Potentially modifiable	Process of care		
			• Time to surgery	/	/
Long	No	Non-modifiable	Physical		
			• Co-morbidity—diabetes	/	/
			• Co-morbidity—respiratory disease	/	/
			• Co-morbidity—stroke	/	/
			• Co-morbidity count	/	/
			• Visual impairment	/[a]	
			• History of hip fracture	/[a]	
			Demographic		
			• Gender	/	/
			• Marital status	/[a]	
			Injury-related		
			• Place of injury—not specified	/	
			Psycho-social		
			• Pre-fracture living alone	/	/
			• Pre-fracture living with spouse	/	
			Socioeconomic		
			• Education	/	/

BA, prognostic factors with strong or moderate level of evidence in baseline analyses; SA, prognostic factors with strong or moderate level of evidence in sensitivity analyses

[a] The evidence level was assigned based on a single study reporting ≥ 2 outcomes

[b] Co-morbidity count had strong evidence of no association with medium-term physical function in the baseline analyses but strong evidence of an association in sensitivity analyses; the latter was based on a single study that reported ≥ 2 outcomes

function beyond discharge. Future study may examine their underlying mechanisms to advise how to improve physical function among those with these co-morbidities. Cognitive impairment is also a known predictor of mortality among older adults with hip fractures [18–20]. This implies that interventions that could improve physical function among this patient subgroup [45, 46] may also reduce mortality.

In contrast, time to surgery, also a known predictor of mortality among older adults with hip fracture, had conflicting evidence and strong evidence of no association with medium- and long-term physical function, respectively. This suggests that surgical delay may not significantly affect recovery of physical function after hip fracture surgery, at least among survivors.

Our study also identified several gaps for future studies of prognostic factors, particularly those related to process of care as well as psychosocial and socioeconomic factors which were less often examined in our list of prognostic factors (Appendices 6–7). The list of prognostic factors could also advise data collection strategies in hip fracture registries for clinical quality monitoring [47] and research.

Limitations

We included studies that measured physical function after discharge from acute setting and synthesized the evidence according to time periods of measurement (≥ 1–6 months vs > 6 months). However, some studies used admission or surgery rather than discharge as their index time of follow-up whereas some were not explicit about the index time. To minimize the impact of such heterogeneity on the validity of the narrative synthesis, we included studies reporting outcomes ≥ 1 month from that study's index time definition, as the impact of such heterogeneous definition diminishes in the longer term. This also accounted for the fact that little recovery occurs within the first month after hip fracture [15]. Nevertheless, we recommend future studies to explicitly report index time of follow-up and be consistent in their reporting.

As we synthesized the evidence across various measures and operationalizations of physical function, the evidence level for each prognostic factor may not be applicable for every measure and operationalization. One consequence of counting each time a prognostic factor is examined against any outcome measure is that this overweighs the evidence for factors assessed in good-quality studies with multiple outcomes. For example, self-efficacy and vitamin D levels were assigned strong or moderate evidence based on findings from a single good-quality study reporting ≥ 2 physical function outcomes. In the absence of an acceptable solution for qualitative synthesis and the small number of prognostic factors affected, we retained the original algorithm, note the relevant prognostic factors in Table 2, and recommend future studies on these factors.

To reduce potential publication bias, we also searched Google Scholar and CINAHL Plus for gray literature and identified two graduate theses. Nevertheless, we could not discount the possibility that publication bias may still be present, as we found a higher number of potentially modifiable prognostic factors having an association with physical function than without.

We used QUIPS checklist [28, 29], one of the most commonly used tools in quality assessment of systematic reviews and followed its recommendations. However, we acknowledge that different quality assessment tools and different thresholds for good quality [48] exist due to the lack of gold standard. To reduce the potential bias due to subjective rating, we performed sensitivity analyses with stricter threshold for good quality and noted when changing the threshold for good quality influenced the results (Tables 1–2).

As the studies only included survivors or individuals contactable for follow-up without accounting for competing risk of death in the analyses, the findings may not be generalizable to individuals who have high risk of death.

We defined "physical function" as "the execution of a task or action by an individual" based on the ICF framework [24], and, hence, our findings may not be generalizable to other definitions of physical function or proxies, such as return to pre-fracture residence. By focusing on pre-discharge prognostic factors, we also did not consider post-discharge factors, such as those related to care processes and structures in post-acute settings. Finally, our findings may not be generalizable to patients < 50 years old and patients receiving conservative treatment for hip fracture. Nevertheless, our study identified a higher number of studies and a more diverse range of prognostic factors than other similar reviews [18, 19, 21, 23].

Conclusion

We identified, organized, and assessed the evidence level of 107 pre-discharge prognostic factors of physical function beyond discharge from 98 studies among older adults ≥ 50 years old following hip fracture surgery. We further examined the sensitivity of our findings using more stringent criteria of quality. Despite the seemingly rich literature on the subject, there are still evidence and quality gaps that should be bridged in future studies, such as in definitions of index time and in reporting attrition. Our analyses point to the need to assess interventions targeting prognostic factors identified in our study alongside usual care to optimize the trajectory of recovery after hip fracture, via systematic reviews or clinical trials.

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Compliance with ethical standards

Conflict of interest Ka Keat Lim, David Bruce Matchar, Jia Loon Chong, William Yeo, Tet Sen Howe, and Joyce SB Koh declare that they have no conflict of interest.

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