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REVIEW

Identification of risk factors for falls in postmenopausal women: a systematic review and meta-analysis

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Abstract

The purpose of this study was to identify risk factors for falls in postmenopausal women and provide evidence for the primary prevention of falls in postmenopausal women. The protocol for this meta-analysis is registered with PROSPERO (CRD42020170927). We searched PubMed, the Cochrane Library and EMBASE for observational studies on the risk factors for falls in postmenopausal women. Review Manager 5.3 was used to calculate the relative risk (RR) or weighted mean difference (WMD) of potential risk factors related to falls. STATA 14.0 was used for the quantitative evaluation of publication bias. Eleven studies with 42,429 patients from 7 countries were included. The main risk factors for falls in postmenopausal women were patient sociodemographic risk factors (age: WMD = 0.37, 95% CI 0.07 to 0.68; body weight: WMD = 0.88, 95% CI 0.56 to 1.12; BMI: WMD = 0.34, 95% CI 0.21 to 0.46; exercise: RR = 0.97, 95% CI 0.94 to 0.99; and FES-I: WMD = 6.60, 95% CI 0.72 to 12.47) and medical risk factors (dietary calcium intake: WMD = − 16.91, 95% CI − 25.80 to − 8.01; previous fracture history: RR = 1.21, 95% CI 1.13 to 1.29; previous falls: RR = 2.02, 95% CI 1.91 to 2.14; number of diseases, > 2: RR = 1.17, 95% CI 1.11 to 1.23; and number of reported chronic health disorders: WMD = 0.30, 95% CI 0.10 to 0.49). Knowledge of the many risk factors associated with falls in postmenopausal women can aid in fall prevention. However, we cannot rule out some additional potential risk factors (age at the onset of menopause, years since last menstruation, hormone therapy and BMD) that need further clinical research.

Keywords Falls · Meta-analysis · Postmenopausal women · Risk factors

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Introduction

Falls are a major public health issue, and the international guidelines for fall prevention for elderly people define a fall as a sudden, involuntary change in posture that causes one to fall to the ground or some lower level but is not caused by violence, loss of consciousness or hemiplegia [1]. As global ageing accelerates, the incidence of age-related health problems, including falls, is increasing [2]. Approximately one-third of elderly people over the age of 65 years fall one or more times each year, and the number increases with increasing age; the annual incidence of falls in elderly people over 80 years old is as high as 50% [3]. A retrospective cohort study of 2094 women from 2005 to 2008 showed that the probability of falls for women over 65 years is 31.9%, which is very harmful in terms of the disability and mortality of older women [4]. Falling can cause severe soft tissue damage and even death in postmenopausal women, making falls a serious health risk in this group [5]. The associated long-term activity limitations eventually cause elderly people to experience negative emotions such as apathy and irritability, which affect their physical and mental health. At the same time, falls and fall-related injuries can cause significant social and economic burdens [6, 7].

In women, the fear of falling (FOF) increases the likelihood of falls [8]. Because of this FOF, they reduce their activities, leading to a decline in their ability to move and in turn increasing their risk of falling [9]. Postmenopausal women undergo a special physiological phase in menopause, and menopause-related changes in metabolic rate, weight and body composition may also lead to limitations in physical function [10]. Menopause is related to some inherent risk factors for falls, such as decreased physical function, increased FOF and postural sway [11], and studies have suggested that obesity and muscle dysfunction are risk factors for falls in postmenopausal women [12]. Many published studies have suggested that independent risk factors for falls in postmenopausal women may be related to smoking, menopausal age, bone density, drug use and previous medical history [11, 13]. However, since the published literature contains mostly single-centre cohort studies, they differ in the identification of certain risk factors (such as alcoholism and hormone use) [14–16], and further research is urgently needed to identify the risk factors for falls in postmenopausal women.

Defining the risk factors for falls can provide evidence for the primary prevention of falls in postmenopausal women. The purpose of this meta-analysis is to quantitatively analyse these risk factors in postmenopausal women. Identifying high-risk factors can be used to target preventive measures to reduce the risk of falling after menopause.

Methods

This meta-analysis was performed in strict accordance with the relevant requirements of the Meta-analysis of Observational Studies in Epidemiology (MOOSE) statement [17]. Additionally, this study was registered on the PROSPERO website https://www.crd.york.ac.uk/PROSPERO/(registration number CRD42020170927).

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) published observational studies, including case-control studies, retrospective cohort studies and prospective cohort studies; (2) study subjects who were postmenopausal women, regardless of age or nationality; (3) studies that clearly involved fall groups and non-fall groups; (4) studies that analysed data on risk factors for falls in postmenopausal women; and (5) studies that were published only in the English language.

The exclusion criteria were as follows: (1) reviews, meeting abstracts and case reports; (2) duplicate publications or studies with identical data; and (3) studies that did not have sufficient data to calculate the means and SDs or with data that were not available to the authors.

Literature retrieval strategy

The PubMed, Cochrane Library and EMBASE databases were searched, and observational studies meeting the inclusion criteria were included. To perform a qualitative analysis and reduce the possibility of missed articles, this study also searched the Cochrane Library (which mainly includes clinical trials). The retrieval time was from the establishment of each database to February 2020, see supplement 1 for the retrieval strategy for each database. We also manually searched all the references of the included studies to identify other studies that might be eligible for inclusion.

Literature screening and data extraction

Two orthopaedic surgeons retrieved the studies, and the preliminary and secondary screening of the studies was conducted in strict accordance with the preestablished inclusion and exclusion criteria. Two researchers independently extracted the data, and a third researcher performed the comparisons. In cases of errors or differences, the third researcher and corresponding author assisted in the final determination.

The data extracted for this study included the title, first author, publication year, country, sample size, mean age, fall definition, fall ascertainment, fall reference period, identified significant risk factors, items relevant for the evaluation of the quality of the study and all possible associated risk factors.

Quality assessment of the included studies

The Newcastle-Ottawa Scale (NOS) was used to evaluate the quality of the included observational studies. The NOS evaluation includes 4 items (4 points) for the evaluation of selection, 1 item (2 points) for the evaluation of the comparability of groups and 3 items (3 points) for the evaluation of the outcome of interest; the highest possible score is 9 points. Studies with a score greater than or equal to 6 are considered high quality, and those with a score less than 6 are considered low quality. The NOS uses a semiquantitative star system to evaluate the quality of studies. If a study meets the standard, it has received 1 star per item, with a total score of 9 points. The higher the score, the higher the quality of the study [18]. Two researchers independently completed the quality evaluations of the included studies. If there were inconsistencies, they were resolved by consultation with the corresponding author.

Statistical analysis

The relative risk (RR) was used to evaluate the effects of binary variables, and the weighted mean difference (WMD) was used to evaluate the effects of continuous variables; the 95% confidence intervals (CIs) of the RR and WMD were calculated. Review Manager 5.3.5 software (Cochrane Collaboration, Oxford, UK) was used to calculate the efficacy and safety indicators and their 95% confidence intervals. In addition, for homogeneous data sets, $P > 0.1$ and $I^2 < 50\%$ were considered the test standards. When the above two statistical conditions were met, a fixed-effect model was used for the meta-analysis because the pooled effect sizes were relatively homogenous. If one of the above standards was not met, the homogeneity of the pooled effect size was not ideal, and the random effects model was applied. If there was a significant difference, a $RR \geq 2$ was considered a high-risk factor, $1 < RR < 2$ was a medium risk factor, and $RR < 1$ was a protective factor.

For heterogeneous risk factor indicators, the process was as follows: if the heterogeneity was large, Review Manager 5.3.5 software was used to evaluate the heterogeneity using the leave one out method. If the source of heterogeneity was identified, the analysis was performed again after the elimination of that study.

To quantitatively assess whether there were publication biases in different risk factor indicators, this study used Stata 14.0 (STATA Corporation, Lakeway, Texas, USA) software to perform Egger and Begg linear regression tests on the outcome indicators included in the combined analysis of 4 or more studies.

Results

Literature screening process and results

A total of 1582 relevant documents were obtained during the preliminary searches of the PubMed ($n = 471$), EMBASE ($n = 879$) and Cochrane Library ($n = 223$) databases and other manual searches ($n = 9$). After excluding duplicate studies, 507 articles were retained. After reading the titles and abstracts, excluding irrelevant studies and applying the inclusion and exclusion criteria, this meta-analysis included 11 prospective cohort studies with 42,429 patients from 7 countries. The study screening process and results are shown in Fig. 1, and basic information about the included studies is presented in Table 1.

Quality evaluation of the included studies

The 11 observational studies included in this meta-analysis are all prospective cohort studies, with study quality evaluation scores of 6–9. According to the NOS criteria, 2 studies received 9 points, 4 studies received 8 points, 4 studies received 7 points and 1 study received 6 points. Each article included in this study had an NOS score greater than or equal to 6 points, indicating that the quality of the studies was very high (Table 2).

Findings from the meta-analysis

Sociodemographic risk factors

We performed a meta-analysis of twelve sociodemographic risk factors: age, body weight, body height, body mass index (BMI), age at the onset of menopause, years since last menstruation, exercise, smoking, and alcohol use, Falls Efficacy Scale International (FES-I) scores, timed up and go test (TUG test) results and five-times sit-to-stand test (5-STS) results (Table 3). Based on the statistical results of the meta-analysis, we identified the following risk factors for falls in postmenopausal women: age (WMD 0.37, 95% CI 0.07 to 0.68), body weight (WMD 0.88, 95% CI 0.56 to 1.12), BMI (WMD 0.34, 95% CI 0.21 to 0.46), exercise (RR 0.97, 95% CI 0.94 to 0.99), smoking (RR 0.78, 95% CI 0.72 to 0.85) and FES-I scores (WMD 6.60, 95% CI 0.72 to 12.47). Among the above statistically significant risk factors, the higher the FES-I score, the more likely a fall event is; thus, this score is a high-risk factor. Interestingly, smoking is a protective factor in postmenopausal women. Older age, lack of physical exercise, weight gain and high BMI all increase the risk of falls in postmenopausal women. However, body height, age at the onset of menopause, years since last menstruation, alcohol use, TUG time and 5-STS time were not found to be direct risk factors for falls in postmenopausal women ($P > 0.05$).

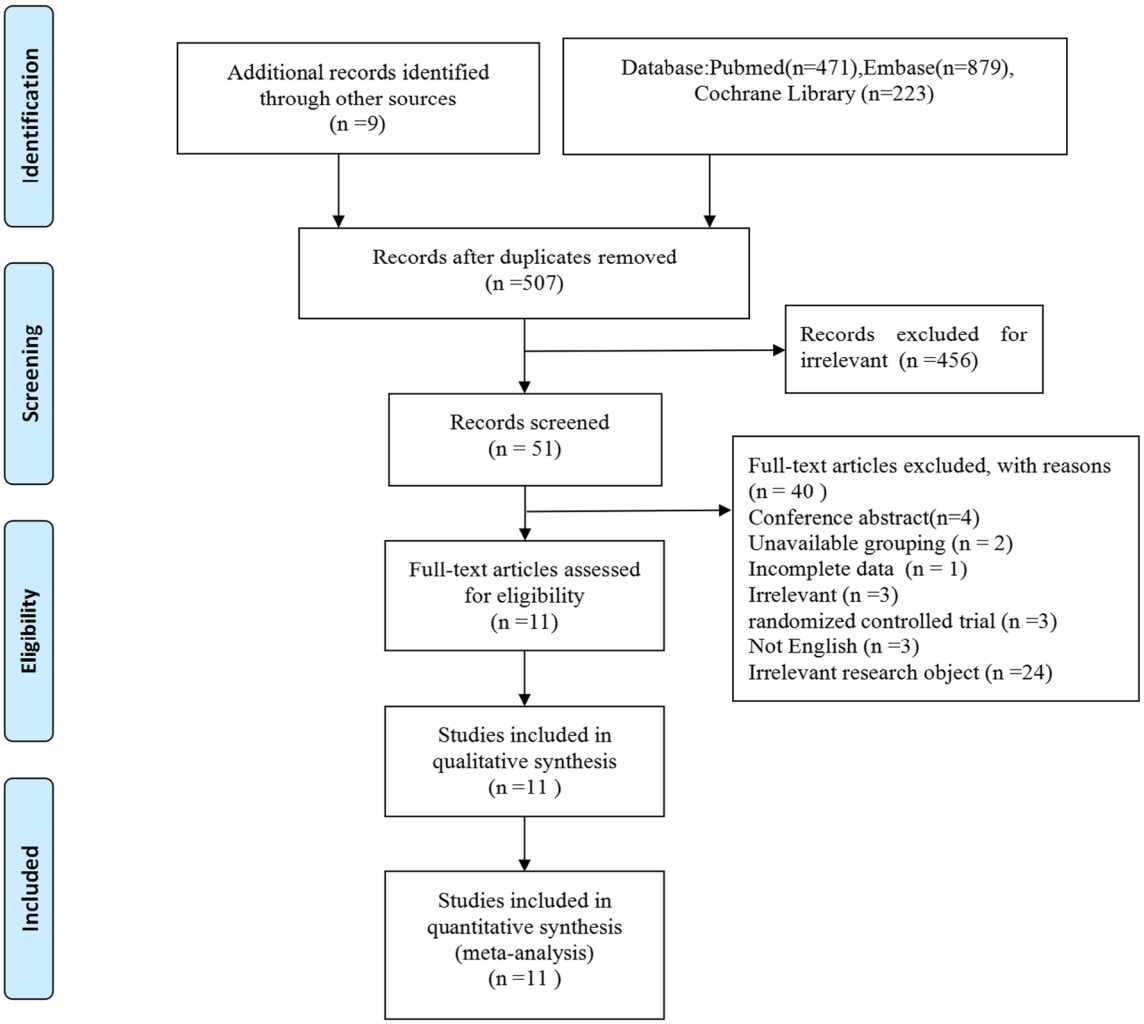

Fig. 1 Flow diagram of the study selection

Medical risk factors

We analysed 7 medical-related risk factors, including dietary calcium intake (mg/day), previous fracture history, previous falls, hormone therapy, number of diseases (> 2), number of reported chronic health disorders and bone mineral density (BMD) of the neck femur (g/cm^3) (Table 3). Based on the combined RRs or WMDs, we identified the following risk factors: previous fracture history (RR 1.21, 95% CI 1.13 to 1.29), previous falls (RR 2.02, 95% CI 1.91 to 2.14), number of diseases, > 2 (RR 1.17, 95% CI 1.11 to 1.23) and number of reported chronic health disorders (WMD 0.30, 95% CI 0.10 to 0.49). In addition, the meta-analysis showed that postmenopausal women who had a fall event had lower levels of calcium intake (low-calcium diet) than postmenopausal women who had not fallen (WMD − 16.91, 95% CI − 25.80 to − 8.01). Considering all the significant risk factors, postmenopausal women who have experienced previous falls have a higher risk of falling again. Postmenopausal women who have a low-calcium diet, have a history of fractures or have more chronic health disorders also have a relatively higher risk of falling. However, hormone use (RR 1.00, 95% CI 0.98 to 1.03) and femoral neck bone density (WMD 0.00, 95% CI − 0.02 to 0.02) are not risk factors for falls.

Evaluation of publication bias

To quantitatively analyse whether there was publication bias in the relevant outcome indicators of this study, we conducted Egger's and Begg's tests on the outcome indicators appearing in 4 or more studies. Begg's tests suggested no significant publication bias in the following risk factors: age ($P = 0.721$), body weight ($P = 0.707$), body height ($P = 0.368$), BMI ($P = 0.348$), age at the onset of menopause ($P > 0.05$), years since last menstruation ($P > 0.05$), exercise ($P = 0.734$) and hormone therapy ($P > 0.05$). The data analysis process and statistical results of the evaluation of publication bias are shown in Supplementary 3.

Table 1 Characteristics of the included studies

Author	Year	Country	Study design	Sample size		Age, years		Fall definition	Fall ascertainment	Fall reference period	Identified significant risk factors
				Fall	Non-fall	Fall	Non-fall				
Chu-Hsu Lin 2016 [19]	2016	Taiwan, China	Co, P	183	770	68.8 ± 8.3	66.4 ± 8.4	Falling with landing on the ground or lower level	Telephone interview	Previous 24 months	Age, hypertension, diabetes
Wojciech Pluskiewicz 2016 [20]	2016	Poland	Co, P	328	650	67.2 ± 7.7	65.2 ± 7.5	"From an upright position"	Interviews	Previous 12 months	Age, rural stay, prior fracture, diabetes type 1, bronchial asthma, and depression
Nadia Afrin 2016 [21]	2016	Finland	Co, P	3593	7001	52.2 ± 2.9	52.3 ± 2.9	"From an upright position"	Self-report	Previous 12 months	Weight, BMI, surgery, current use of prescribed medications, smoking, previous fracture
Nadia Afrin 2018 [22]	2018	Finland	Co, P	3397	5259	62.1 ± 2.9	62.2 ± 2.9	"From an upright position"	Self-report	Previous 12 months	BMI, number of prescribed medications, number of chronic diseases, mobility, smoker, alcohol, number of women with musculoskeletal disorders
B.Drozdzowska 2013 [23]	2013	Poland	Co, P	211	407	67.6 ± 7.9	65.6 ± 7.7	NR	Interviews	Previous 12 months	Age, height, menopause, instrumental activity of daily living
Yuksel Ersoy 2009 [24]	2009	Turkey	Co, P	35	90	64.5 ± 8.1	60.2 ± 7.5	Unintentionally coming to rest on the ground, floor, or other lower level	Self-report	Previous 12 months	Age, Berg Balance Scale, TUG test, FES-I, fear
F. Hita-Contreras 2013 [25]	2013	Spain	Co, P	20	76	56.6 ± 4.2	57.9 ± 3.9	An unexpected event in which the participants come to rest on the ground, floor, or lower level	Interviews	Previous 12 months	FES-I, velocity, sway area
Kerri M. Winters-Stone 2011 [26]	2011	USA	Co, P	34	25	59.2 ± 7.1	57.4 ± 12.4	Unintentionally coming to rest on the ground or at some other lower level, not as a result of a major intrinsic event or overwhelming hazard	Self-report	Previous 6 months	Balance disturbances of vestibular origin, delays in detecting low contrast visual stimuli
Shawna Follis 2018 [27]	2018	USA	Co, P	2509	7415	50–79	50–79	Fall and land on the floor or ground	Self-report	Previous 12 months	Sarcopenic obesity
Kaisa M. Randell 2001 [28]	2001	Finland	Co, P	3049	6743	57.5 ± 2.8	57.6 ± 2.9	NR	Self-report	Previous 12 months	Weight, number of disorders, dairy Ca intake, physically active, smoking
Abdulrahim A. Rouzi 2015 [29]	2015	Saudi Arabia	Co, P	91	543	61.64 ± 5.69	59.6 ± 5.95	Asudden unintentional change in position causing an individual to land at a lower level on an object, on the floor, or on the ground	Interviews	Previous 12 months	Age, time since menopause, bone mineral density, handgrip strength, TUG test

Co, cohort study; *P*, prospective study; *NR*, not report; *TUG*, timed up and go; *BMI*, body mass index; *FES-I*, Falls Efficacy Scale International

Table 2 Newcastle-Ottawa Scale for risk of bias assessment of cohort studies included in the meta-analysis

Study	Selection				Comparability	Outcome			Overall
	Representativeness of exposed cohort	Selection of non-exposed	Ascertainment of exposure	Outcome not present at start		Assessment of outcome	Adequate follow-up length	Adequacy of follow-up	
Chu-Hsu Lin 2016 [19]	☆	★	★	★	★	★	★	★	7
Wojciech Pluskiewicz 2016 [20]	☆	★	★	☆	★★	★	★	★	7
Nadia Afrin 2016 [21]	★	★	★	★	★	★	★	★	8
Nadia Afrin 2018 [22]	★	★	★	☆	★	★	★	★	7
B. Drozdzowska 2013 [23]	★	★	★	★	★	★	★	★	8
Yuksel Ersoy 2009 [24]	☆	★	★	★	★	★	★	★	7
F. Hita-Contreras 2013 [25]	☆	★	★	★	★★	★	★	★	8
Kerri M. Winters-Stone 2011 [26]	☆	★	★	★	★	★	★	☆	6
Shawna Follis 2018 [27]	☆	★	★	★	★★	★	★	★	8
Kaisa M. Randell 2001 [28]	★	★	★	★	★★	★	★	★	9
Abdulrahim A. Rouzi 2015 [29]	★	★	★	★	★★	★	★	★	9

★, score of 1; ★★, score of 2; ☆, score of 0

Discussion

Falling often leads to restricted activities, social isolation, increased disability and death. Therefore, it is important to identify the risk factors for falls and implement preventive measures early. For the first time, this meta-analysis systematically and quantitatively analysed the correlations between falls and some potential risk factors in postmenopausal women, which may be helpful for informing strategies for the prevention of falls in this group in the future. We analysed 19 sociodemographic risk factors and medical risk factors in postmenopausal women. The meta-analysis results showed that older age, higher body weight, higher BMI, lack of physical exercise, higher FES-I scores, previous fracture history, previous falls and more coexisting diseases are risk factors for falls in postmenopausal women.

Sociodemographic risk factors

We found that older age is a major risk factor for falling in postmenopausal women. When we combined the results from 10 studies, the level of heterogeneity was 85%, and the difference was statistically significant ($P = 0.02$). When we removed the source of heterogeneity through a sensitivity analysis and performed the statistical analysis again, the level of heterogeneity was 52%, and the difference was statistically significant ($P < 0.0001$). The meta-analysis showed that older age is a risk factor for falls, and the statistical results are stable and reliable. During menopause, women's hormone levels decrease each year, and their physical function declines more rapidly than that of men [30, 31]. Therefore, as menopausal women grow older, their physical functions, muscle functions and stability may weaken, thus increasing the risk of falling. Being overweight and having a higher BMI also increase the risk of falls in postmenopausal women. In an 8-year cohort study, Christine L et al. [32] found that weight gain was positively correlated with the risk of falling. Studies have shown that a higher BMI in older women increases their risk of falling; weight gain is closely related to hormonal changes in postmenopausal women, an increase in the incidence of flatfoot and a decline in lower-limb muscle quality [33, 34]. Obese elderly women have high lean leg masses but lack muscle strength, so they have poor balance and stability and are prone to falls [35]. Additionally, this meta-analysis shows that body height is not a risk factor for falls in postmenopausal women (WMD −0.16, 95% CI −0.40 to 0.08). It can be concluded that obesity and weight gain are associated with a higher risk of falling. We found that a lack of physical exercise also leads to an increased risk of falls. Research has shown that strengthening physical exercises constitutes an important means of enhancing balance, improving physical fitness and reducing falls in elderly people [36]. Strengthening physical exercises can help increase muscle strength and enhance the

Table 3 The main outcomes of meta-analysis and subgroup analysis

Risk factors	No. of studies	RR or WMD	LL 95% CI	UL 95% CI	*P* value	I^2 (%)	Analysis model
Sociodemographic risk factors							
Age, years	10	0.37†	0.07	0.68	*0.02*	85	IV, random
Age (eliminate heterogeneous sources)	7	1.83†	0.93	2.73	*< 0.0001*	52	IV, random
Body weight, kg	6	0.88†	0.56	1.21	*< 0.00001*	0	IV, fixed
Body height, cm	7	− 0.16†	− 0.40	0.08	0.20	56	IV, random
BMI (kg/m^2)	9	0.34†	0.21	0.46	*< 0.00001*	0	IV, fixed
Age of menopause, years	5	− 0.31†	− 0.91	0.29	0.31	64	IV, random
Years since last menstruation, years	4	0.01†	− 0.15	0.16	0.94	37	IV, fixed
Exercise (yes vs. no)	4	0.97*	0.94	0.99	*0.01*	0	M-H, fixed
Smoking (yes vs. no)	3	0.78*	0.72	0.85	*< 0.00001*	0	M-H, fixed
Alcohol use, heavy use, > 30 drinks/month (yes vs. no)	2	0.98*	0.85	1.13	0.77	43	M-H, fixed
FES-I, point	2	6.60†	0.72	12.47	*0.03*	79	IV, random
TUG test, second	2	1.32†	− 1.21	3.86	0.31	90	IV, random
5-STS, second	3	0.30†	− 0.36	0.96	0.37	0	IV, fixed
Medical risk factors							
Dietary calcium intake, mg/day	3	− 16.91†	− 25.80	− 8.01	*0.0002*	7	IV, fixed
Previous fracture history (yes vs. no)	3	1.21*	1.13	1.29	*< 0.00001*	0	M-H, fixed
Previous fallers (yes vs. no)	3	2.02*	1.91	2.14	*< 0.00001*	0	M-H, fixed
Hormone therapy (yes vs. no)	4	1.00*	0.98	1.03	0.80	0	M-H, fixed
Number of diseases, > 2 (yes vs. no)	2	1.17*	1.11	1.23	*< 0.00001*	0	M-H, fixed
Number of reported chronic health disorders	2	0.30†	0.10	0.49	*0.003*	94	IV, random
BMD, g/cm^3, neck femur	2	0.00†	− 0.02	0.02	1.00	0	IV, fixed

Note: The forest map of all risk factors is shown in Supplementary appendix 2

TUG, timed up and go; *5-STS*, five-times sit-to-stand; *BMI*, body mass index; *FES-I*, Falls Efficacy Scale International; *BMD*, bone mineral density; *RR*, relative risk; *WMD*, standardized mean differences; *LL*, lower limit; *UL*, upper limit; *M-H*, Mantel Haenszel test; *IV*, inverse variance

*RR

† WMD

stability and balance of the body, thus reducing the risk of falls [37]. The higher the FES-I score is, the greater the risk of falling and the FOF. A large-scale clinical study [8] showed that the FOF is common in elderly women, with falls mainly being caused by obstacles to balance and movement. Because of the FOF, older women tend to restrict their activities, which leads to a decline in their mobility and loss of physical independence, in turn increasing their actual risk of falling [9]. Therefore, psychological interventions for postmenopausal women to help them overcome the FOF are very helpful to prevent falling. Interestingly, smoking is a protective factor rather than a risk factor for falling in postmenopausal women. Smoking is extremely harmful to the human cardiac and respiratory systems, and the deterioration of cardiopulmonary function theoretically affects people's daily lives, including reducing activity [38, 39], which may in turn reduce the risk of falling. In addition, smoking itself is a behavioural intermediary, and this behaviour does not directly reduce the risk of falling. However, the decline in physical function caused by smoking, which reduces body activity, may reduce the risk of falling. Furthermore, we found no evidence to suggest that the risk of falls in postmenopausal women is related to body height, age at the onset of menopause, years since last menstruation, alcohol use, or TUG and 5-STS test results.

Medical risk factors

The results of this meta-analysis showed that postmenopausal women on a low-calcium diet were more likely to fall than postmenopausal women who regularly consumed calcium (WMD − 16.91, 95% CI − 25.80 to − 8.01). Therefore, this study shows that calcium-containing diets may be helpful for preventing falls in postmenopausal women. However, whether supplemental calcium is necessary and the means of quantifying the intake of calcium need further research. Postmenopausal women's oestrogen levels decrease, their bone mass decreases significantly, and osteoporosis is likely to occur, which in turn affects bone resistance to fractures [40, 41]. Therefore, proper postmenopausal calcium supplementation (a calcium-containing diet) is helpful for preventing falls.

Postmenopausal women with a history of fractures and falls are more likely to fall again. In fact, the fracture history of elderly individuals, especially elderly women, is mostly a result of falling, making it a causal factor [42, 43]. People who have suffered fractures tend to limit their daily activities and simultaneously experience negative emotions such as depression, anxiety and decreased self-confidence. The FOF reduces flexibility, independence and balance of the body, thereby increasing the risk of falls [44, 45]. We also found that the more chronic health disorders postmenopausal women have, the more likely they are to fall. Indeed, studies have shown that chronic health disorders have important psychological and physical effects on older people [46]. Discomfort caused by chronic health disorders, such as chronic obstructive pulmonary disease and knee osteoarthritis, can reduce a patient's mobility and ability to cope with potential fall hazards in the environment, which increase the risk of falls in elderly patients [47, 48]. This meta-analysis found that the risk of falls in postmenopausal women was not associated with hormone use or femoral neck bone density. Despite these findings, we cannot exclude these two variables as potential risk factors, as studies have suggested that hormone use and bone mineral density are closely related to the fall risk in postmenopausal women [29, 49, 50]. Therefore, we recommend further clinical studies of these variables.

Limitations

Several study limitations were unavoidable. First, the sample size of 11 studies included in this analysis means that the differences among the studies were relatively large, potentially leading to heterogeneity and affecting the results. Second, some of the risk factors that we expected to have a positive association, such as bone density and menopausal age, had a negative association in our findings, which may be related to the small number of studies we included. Third, due to limitations of the original data, we still lack research on potential risk factors such as drug use, family-related factors and serum levels of 25-hydroxyvitamin D, which are factors that need attention in future research. Fourth, since the risk of falling is a universal problem, the restriction of the included studies to those published in English papers is a major limitation.

Conclusion

Our findings provide some guidance for postmenopausal women and healthcare workers seeking to prevent falls. This meta-analysis found that sociodemographic risk factors (age, body weight, BMI, lack of exercise, FES-I scores) and medical risk factors (dietary calcium intake, previous fracture history, previous falls, number of diseases (> 2), number of reported chronic health disorders) are risk factors for falls in postmenopausal women.

Despite these findings, we still cannot rule out the possibility that some other variables are also risk factors (age at the onset of menopause, years since last menstruation, hormone therapy and bone mineral density). We recommend further clinical studies of these variables to obtain more persuasive evidence.

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Availability of data and material All data and materials are contained within the manuscript.

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Compliance with ethical standards

Conflicts of interest None.

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