

A systematic review and meta-analysis of fall incidence and risk factors in elderly patients after total joint arthroplasty

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Abstract

Background: Falls in the elderly have become a serious social problem worldwide. Approximately a third of persons fall at least once in the year after total joint arthroplasty (TJA), but preventing and treating falls is still challenging in clinical practice. Until now, no formal systematic review or meta-analysis was performed to summarize the risk factors of falls after TJA. The present study aimed to quantitatively and comprehensively conclude the risk factors of falls after TJA in elderly patients.

Methods: The electronic databases to be searched include CNKI, Embase, Medline, and Cochrane central database (all up to November 2018). All studies on the risk factors of falls after TJA in elderly patients without language restriction were reviewed. Process of evaluation of identified studies and extraction of data were independently conducted by 2 reviewers, qualities of included studies were assessed using the Newcastle–Ottawa Scale. Data were pooled and a meta-analysis completed. All analyses were performed by the software Stata 11.0.

Results: A total of 14 studies were included, which altogether included 1284456 patients with TJA, of them 12879 cases of falls occurred after surgery, suggesting the accumulated incidence of 13.1% and the prevalence of in-hospital falls was 1.0%. This study has provided evidence for the preventing of falls in the elderly patients who were underwent TJA. Outcome measures include advanced age, female, Overweight (BMI ≥ 25 kg/m²), falls history, use of walking aid, diabetes, cardiac disease, hypertension, COPD and depressive symptoms. The ABC Scale was significantly negatively correlated with falls after lower extremity joint replacement.

Conclusions: Related prophylaxis strategies should be implemented in elderly patients involved with above-mentioned risk factors to prevent falls after TJA.

Abbreviations: ABC Scale = Activities-specific Balance Confidence Scale, BMI = body mass index, COPD = chronic obstructive pulmonary disease, NOS = newcastle–ottawa scale, OA = osteoarthritis, OR = odd ratio, SMD = standard mean difference, THA = total hip arthroplasty, TJA = total joint arthroplasty, TKA = total knee arthroplasty.

Keywords: elderly patients, falls, incidence, risk factors, total joint arthroplasty

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1. Introduction

Osteoarthritis (OA) of the knee and hip is a common debilitating chronic condition affecting the elderly population,^[1,2] and total knee arthroplasty (TKA) and total hip arthroplasty (THA) are widely believed to be the best choice for the treatment of end-stage OA, and the procedure can significantly relieve pain and restore physical functioning and improve the quality of life for these patients.^[3,4]

Falls in the elderly have become a serious social problem,^[5,6] and lower limb OA is also a major risk for falls with up to 50% reporting falling each year, which almost double the 33% reported in dwelling ageing people.^[7–9] Pain and disability often persist following the total joint arthroplasty (TJA) surgery which may predispose to increased risk of falling.^[10,11–13] Approximately a third of persons fall at least once in the year after TKA or THA,^[14–16] the number of falls reported following TKA ranges between 14.1 and 38.3%.^[17–20]

Three studies have investigated falls in the pre or postoperative period for TJA patients, which providing new insights into the factors that likely lead to falls.^[16,17,21] A preoperative history of falls, depressive symptoms, and THA vs TKA are associated with an increased risk of postoperative falls in aged patients undergoing lower extremity joint replacement.^[16,21] Compared to TJA, majority of the presented studies focused on falls in

patients following TKA. Risk factors of falls following TKA have been attributed to several factors such as falls history, higher preoperative depression, and persistence of impaired lower limb proprioception postoperatively.^[21–23] However, these existing studies have generally been too small to investigate multivariate analyses of predictive factors associated with falls.

Evaluation of post-operative falls and the associated risk factors is therefore warranted. Until now, no formal systematic review or meta-analysis was performed to summarize the risk factors of falls in the elderly after lower extremity joint replacement to obtain a definitive conclusion. Therefore, in this study, we summarized these risk factors from the previous original researches and conducted a meta-analysis that will be most informative in guiding clinicians for identifying high risk patients and help clinicians to prevent postoperative falls and improve the prognosis of patients.

2. Materials and methods

2.1. Literature search

CNKI, Embase, Medline, and Cochrane central database were searched using a broad range of terms to identify original research, published all through October 2018 and selecting potential studies to consider. The main key words were as follows: “factor” or “predictor” or “risk” AND “falls” AND “knee arthroplasty” or “hip arthroplasty” or “knee replacement” or “hip replacement” AND “elderly”. Also, a manual search of references in the identified articles and systematic reviews was performed for possible inclusion.

2.2. Eligibility criteria

Two reviewers (Xintao Wu and Hao Liu) independently evaluated the titles and abstracts of the identified studies. Only full-text articles without language restriction were included in

this meta-analysis. The following inclusive selection criteria were applied:

1. a study was performed to explore risk factors for falling in patients after TKA or THA;
2. elderly people (≥ 60 years old) who underwent TKA or THA;
3. cases and controls were defined based on the fallers or non-fallers;
4. A fall was defined as unintentionally coming to rest on the ground, or a lower level,^[24] and falls due to extraordinary environmental factors (e.g., falls while riding a bicycle and traffic accidents) and fainting were excluded;
5. sufficient data was published for estimating an odds ratio (OR) or standardized mean difference (SMD) with 95% confidence interval (95% CI).

2.3. Quality of included studies

The quality of the included studies was evaluated using the Newcastle–Ottawa Scale (NOS) based on the 3 main items: the selection of the study groups (0–4 points),^[25] the comparability of the groups (0–2 points) and the determination of either the exposure or the outcome of interest (0–3 points), with a perfect score of 9.

2.4. Data extraction

All the data were carefully extracted from all eligible studies independently by the 2 reviewers (Xintao Wu and Hao Liu). The following variables were extracted from each study: first authors name, publication year, country, significant risk factors, definitions and numbers of cases and controls and numbers of citations for each potential risk factor for falling after lower extremity joint replacement surgery. Any disagreement was resolved by discussion and consensus. The literature search and data extraction strategy were shown in the Figure 1.

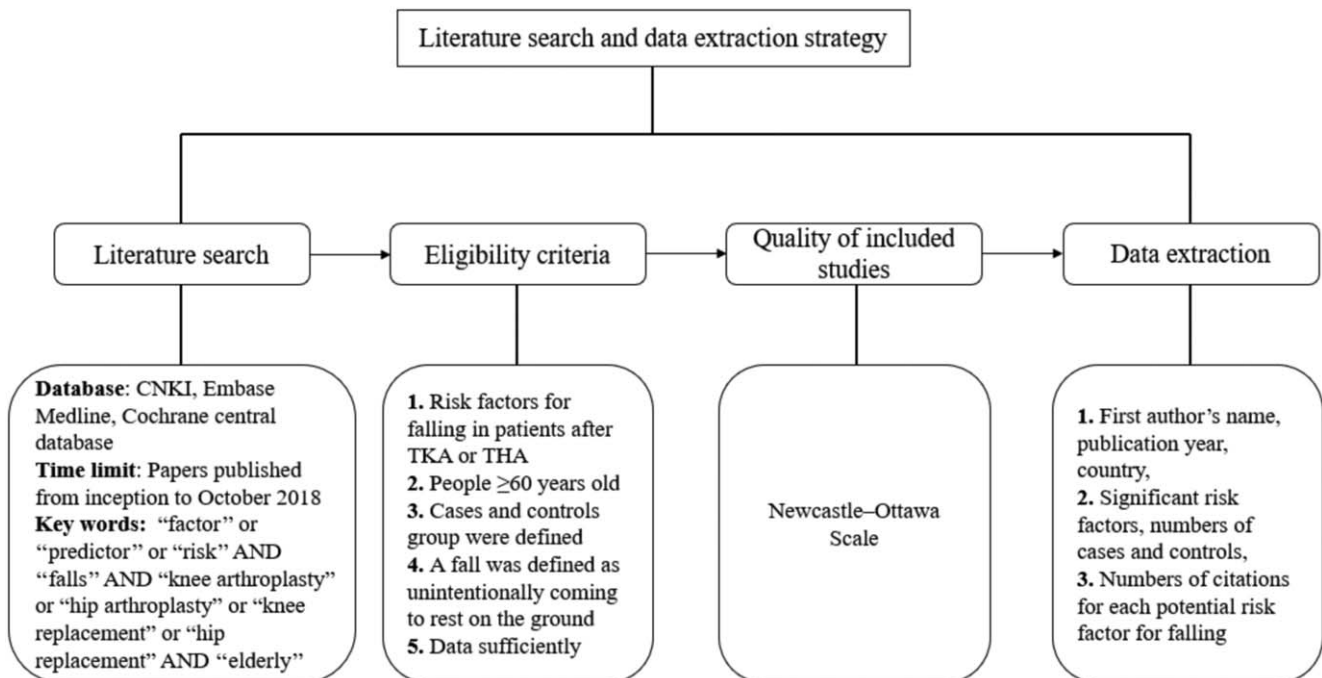


Figure 1. Literature search and data extraction strategy of this study.

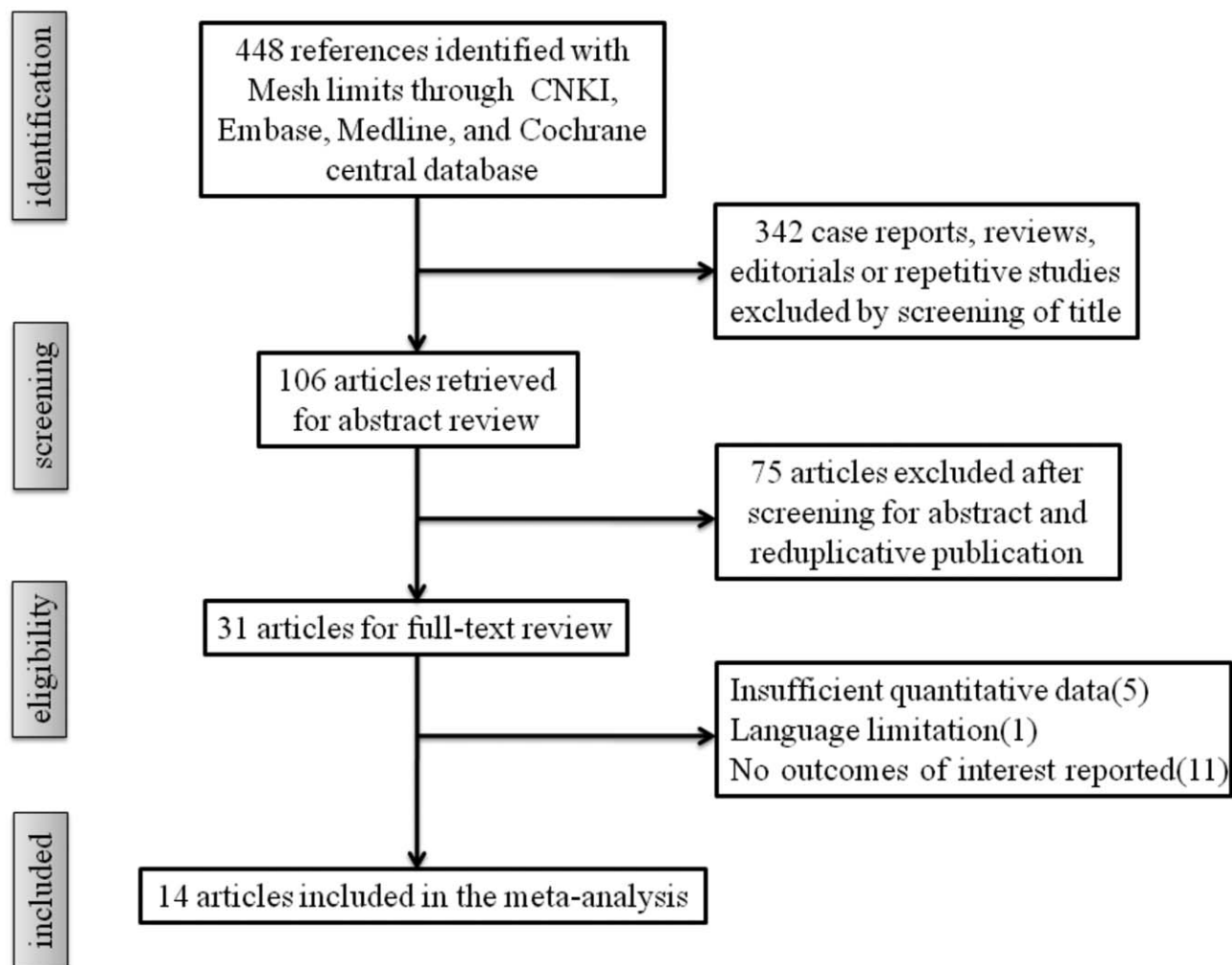


Figure 2. Flow diagram showing the process of selection for meta-analysis.

This study was approved by the Institutional Review Board of Cangzhou Integrated Traditional Chinese and Western Medicine Hospital.

2.5. Statistical analyses

ORs or SMDs and corresponding 95% CI were estimated and pooled across studies to assess the association between different variables and the risk of falls with a value of $P < .05$ as significant. Heterogeneity among studies was tested by Q-test statistics with significance set at $P < .10$ and further measured by I^2 statistics with I^2 more than 50% indicating significant inconsistency.^[26] A random-effect model was used to calculate pooled ORs in the case of significant heterogeneity ($P < .10$ or $I^2 > 50%$); otherwise, a fixed-effect model was used.^[27] The outcome of meta-analysis for variables was summarized graphically using a forest plot. If necessary, a sensitive analysis by excluding outlier study one by one was conducted to investigate the sources for heterogeneity. Potential publication bias was detected by Beggs funnel plots, and $P < .05$ was judged as statistically significant. All analyses were performed by the software Stata 11.0 (Stata Corporation, College Station, TX).

3. Results

3.1. Characteristics of identified studies

Figure 2 indicates the flowchart of the article screening and the detailed selection process. Initial search yielded 448 titles and abstracts from the electronic databases. After duplicates were removed, 106 abstracts were reviewed for initial screening and 31 for the next stage of review. After inclusion and exclusion criteria were applied, 14 full text articles were chosen for this meta-analysis. All were published in English with publication time from 2012 to 2018. These 14 studies altogether included 1284456 patients, 12879 cases of falling occurred after lower extremity joint replacement, suggesting the accumulated incidence of 13.1% and the prevalence of in-hospital falls was 1.0%. Detailed information about these included studies is shown in Table 1.

3.2. Methodological quality assessment

The outcome of methodology quality assessment was as follows: 7 studies^[14,16,17,19,20,28,29] scored 8, 5 studies^[18,21,22,30,31] scored 7 and 2 studies^[23,32] scored 6.

Table 1
Detailed information on the basic characteristics of the 14 included studies and participants.

Author	Country	Publication year	Age (mean ± SD, year)	Fallers	Non-fallers	total	Significant factors	NOS score
Matsumoto	Japan	2012	75.5 ± 6.0	23	47	70	Postoperative range of knee flexion and ankle plantar flexion	8
Memtsoudis	USA	2012	67.40	9198	1078804	1088002	Male, primary THA, primary TKA, advanced age, Pulmonary circulatory disease, alcoholism, chronic lung disease, congestive heart failure, coagulopathy, neurologic disease, electrolyte/fluid abnormalities, Pulmonary circulatory disease	7
Swinkels	UK	2013	75.9 ± 5.1	5	22	27	All the variables have no significance	6
Wasserstein	Canada	2013	66 ± 11.0	60	2137	2197	Advanced age, BMI, femoral nerve blockade	8
Jørgensen	Denmark	2013	67.40	83	506	589	Age, living alone, psychiatric disease,	8
Matsumoto	Japan	2014	75.9 ± 2.3	31	50	81	Kyphosis	8
Memtsoudis	USA	2014	66.30	3042	188528	191570	Advanced age, higher comorbidity burden, more major complications, general anesthesia	7
Ikutomo	Japan	2015	66.0 ± 8.7	77	137	214	Medication, postoperative duration	7
Tsonga	Greece	2016	73.00 ± 5.28	15	68	83	Advanced age, history of falls, fear of falls	7
Riddle	USA	2016	63.9 ± 8.6	75	413	488	Advanced age, female, depressive symptoms, prior falls	8
Levinger	Australia	2017	66.70	82	161	243	Reduced SF-36v2 general health sub-scale, increased planned physical activity and previous falls	8
Chan	China	2018	66.7 ± 6.7	23	111	134	Younger age, reduced proprioception, reduced sensory orientation, greater operated knee pain	6
Ikutomo	Japan	2018	62.6 ± 8.7	51	111	162	Gait abnormality, history of falls	8
Riddle	USA	2018	68.18	114	482	596	Female, depressive symptoms, comorbidity, Narcotic use, history of falls	7

3.3. Age and gender

Ten studies reported the admission age of 68.9 years in postoperative falls after lower extremity joint replacement, which was 3.2 years older than that in non-fallers groups, and the pooled results for meta-analysis suggested a significant difference (OR 1.05; 95% CI 1.01–1.09; Fig. 3A), but with a significant heterogeneity ($P < .001$, $I^2 = 86.0\%$; Table 2). However, after sensitive analysis by excluding outlier studies, the I^2 value lowered to 45.7%, and the significance did not change, indicating the result was reliable. Beggs funnel plot for publication bias investigated no age difference between fallers and non-fallers after lower extremity joint replacement ($P = .210$; Fig. 4). Sex difference of the occurrence of falls after lower extremity joint replacement was reported in 8 studies. Results of meta-analysis showed that females were more likely to fall, and the combinable OR was 1.62 (95% CI 1.36–1.09; Fig. 3B), with no heterogeneity ($P = .510$, $I^2 = 0$; Table 2).

3.4. Body mass index (BMI)

Eight studies reported the BMI of 26.88 kg/m² in fallers falls after lower extremity joint replacement, which is 0.11 kg/m² higher than that in non-fallers groups, and the pooled results

for meta-analysis suggested no difference (SMD -0.01; 95% CI -0.13–0.11). Three individual studies compared the overweight (BMI ≥ 25 kg/m²) between fallers and non-fallers. Meta-analysis of these studies showed that overweight patients appeared more prone to falling (OR 1.18, 95% CI 1.08–1.29; Table 2; Fig. 3C).

3.5. Falls history

Postoperative falls incidence was consistently higher in those who had falls history compared with those who did not. A total of 7 studies reported the falls history as a risk factor and meta-analysis of these studies showed that patients with falls history were more prone to falling after lower extremity joint replacement (OR 3.56, 95% CI 1.96–6.47), with observed heterogeneity ($P < .001$, $I^2 = 79.9\%$; Table 2; Fig. 3D).

3.6. Walking aid

Five studies mentioned walking aid. The meta-analysis showed there was significant difference (OR 1.71; 95% CI 1.19–2.47). There was no evidence of heterogeneity among studies ($P = .679$, $I^2 = 0$; Table 2; Fig. 3E).

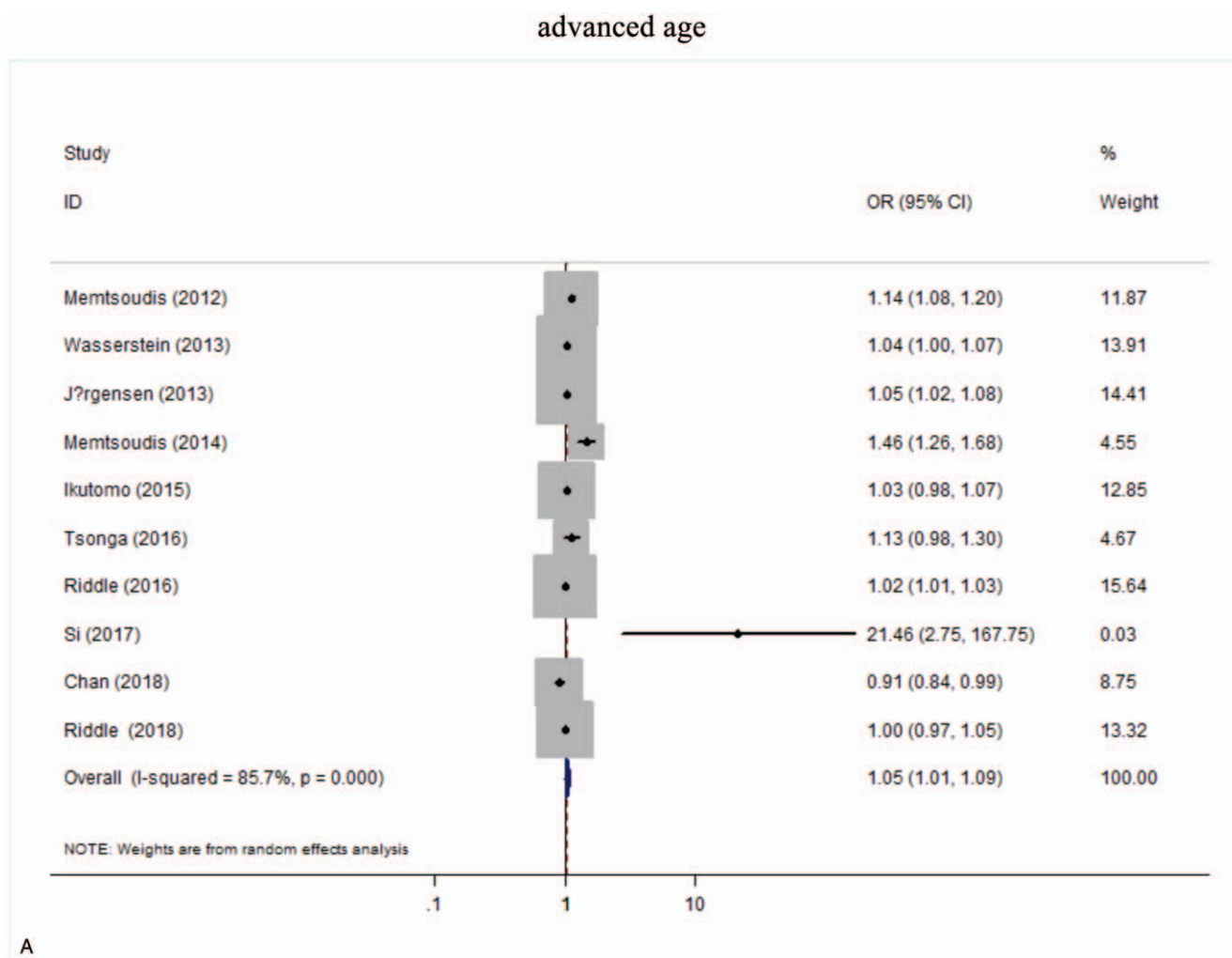


Figure 3. A: Patients with the risk factors of advanced age. B: Patients with the risk factors of female. C: Patients with the risk factors of overweight (BMI ≥ 25 kg/m²). D: Patients with the risk factors of falls history. E: Patients with the risk factors of the use of walking aid. F: Patients with the risk factors of diabetes. G: Patients with the risk factors of cardiac disease. H: Patients with the risk factors of hypertension. I: Patients with the risk factors of COPD. J: Patients with the risk factors of depressive symptoms. K: Patients with the risk factors of Higher ABC Scale was less likely to develop falls after TJA.

3.7. Medical comorbidities

Five studies reported diabetes. Using a fixed-effects model, we observed a significant difference of this factor (OR 1.39; 95% CI 1.10–1.77; Table 2; Fig. 3F), with no heterogeneity ($P = .353$, $I^2 = 9.3\%$; Table 2). Eight studies paid close attention to the relationship between cardiac disease and falls after lower extremity joint replacement. Meta-analysis of these 8 studies showed that cardiac disease patients were more likely to fall (OR 1.25; 95% CI 1.14–1.38; Table 2; Fig. 3G), with no heterogeneity ($P = .415$, $I^2 = 1.9\%$; Table 2). Hypertension showed the strongest association with recent falls (OR 1.10; 95% CI 1.02–1.18; Table 2; Fig. 3H), with no heterogeneity ($P = .882$, $I^2 = 0$; Table 2). In patients, the percentage of Chronic Obstructive Pulmonary Disease (COPD) was significantly higher in fallers than non-fallers (OR 1.11; 95% CI 1.01–1.23; Table 2; Fig. 3I), with no heterogeneity ($P = .183$, $I^2 = 41.0\%$; Table 2). Moreover, depressive symptoms had a significantly increased risk of fall (OR 1.11; 95% CI 1.01–1.23; Table 2; Fig. 3J), with a significant heterogeneity.

3.8. Activities-specific Balance Confidence Scale (ABC Scale)

The ABC is a measure of balance confidence.^[33] The ABC Scale was significantly negatively correlated with falls after lower extremity joint replacement (SMD -0.21 ; 95% CI -0.42 – 0 ; Fig. 3K).

4. Discussion

Falls in persons with arthroplasty are common. Previous studies have found in-hospital fall rates after TJA surgery of about 1%, and the prevalence of falls between 14 and 40% in discharged patients 6 and 12 months following TJA.^[17,20] Results in this meta-analysis suggested the accumulated incidence of 13.1% and the prevalence of in-hospital falls was 1.0%. Fall prevention interventions have been extensively studied and found to be effective.^[34] Fall incidence and associated injuries may be potentially reduced by identifying patients at increased risk and providing targeted intervention delivered by rehabilitation

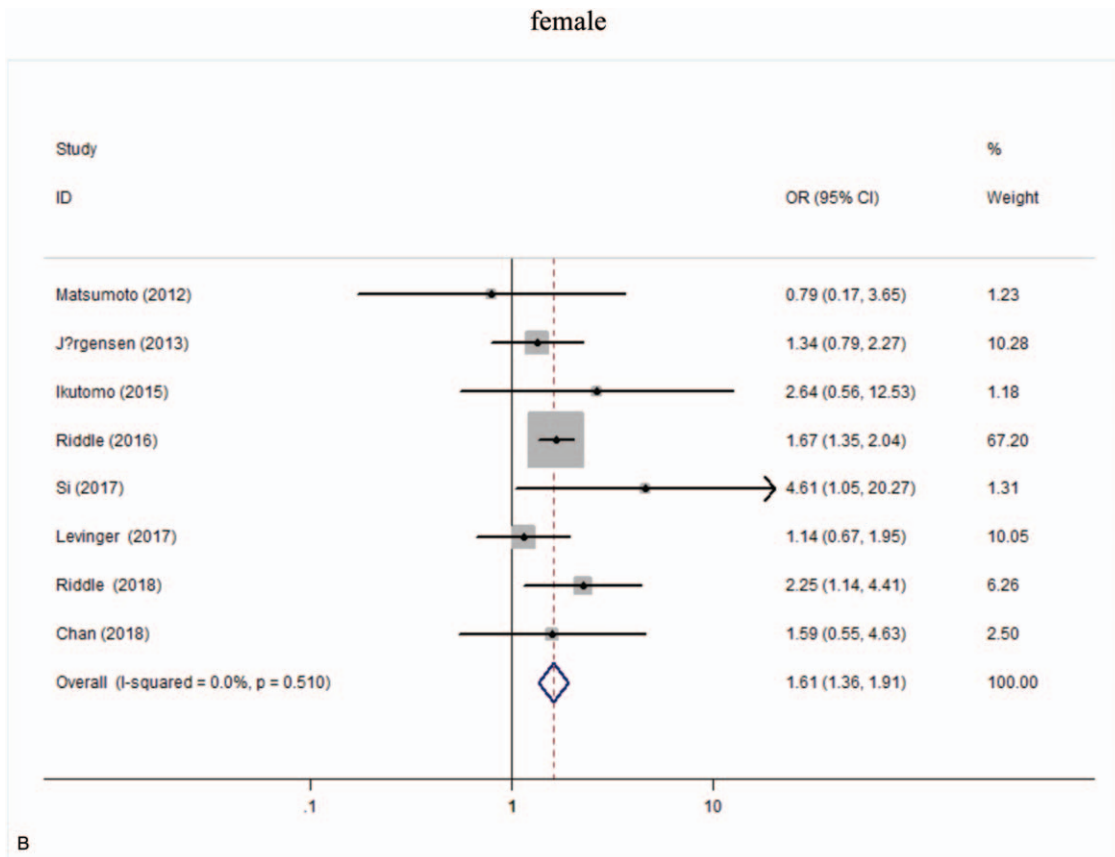


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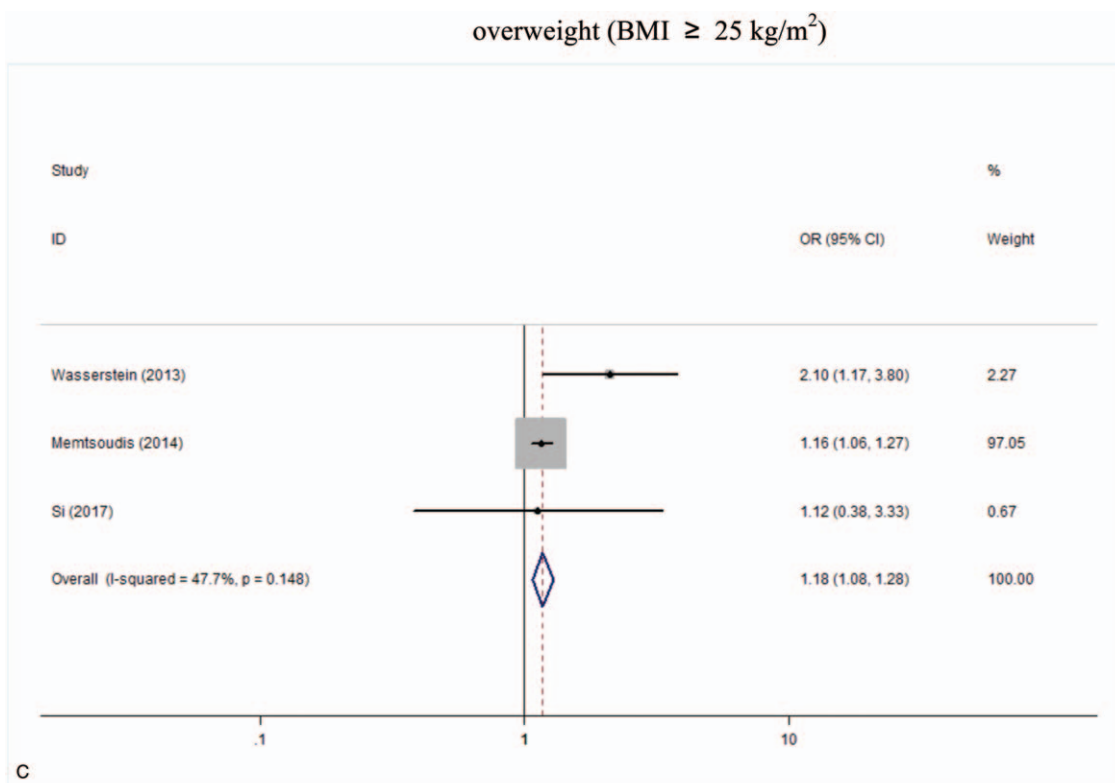


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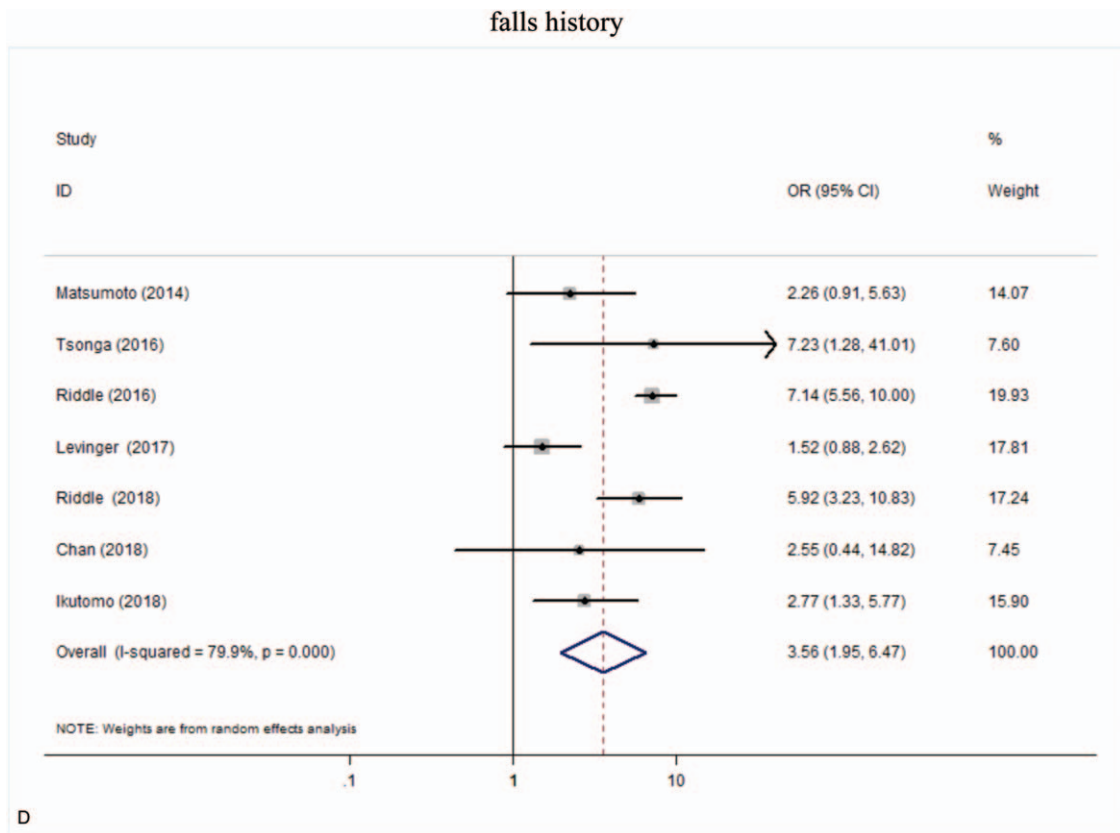


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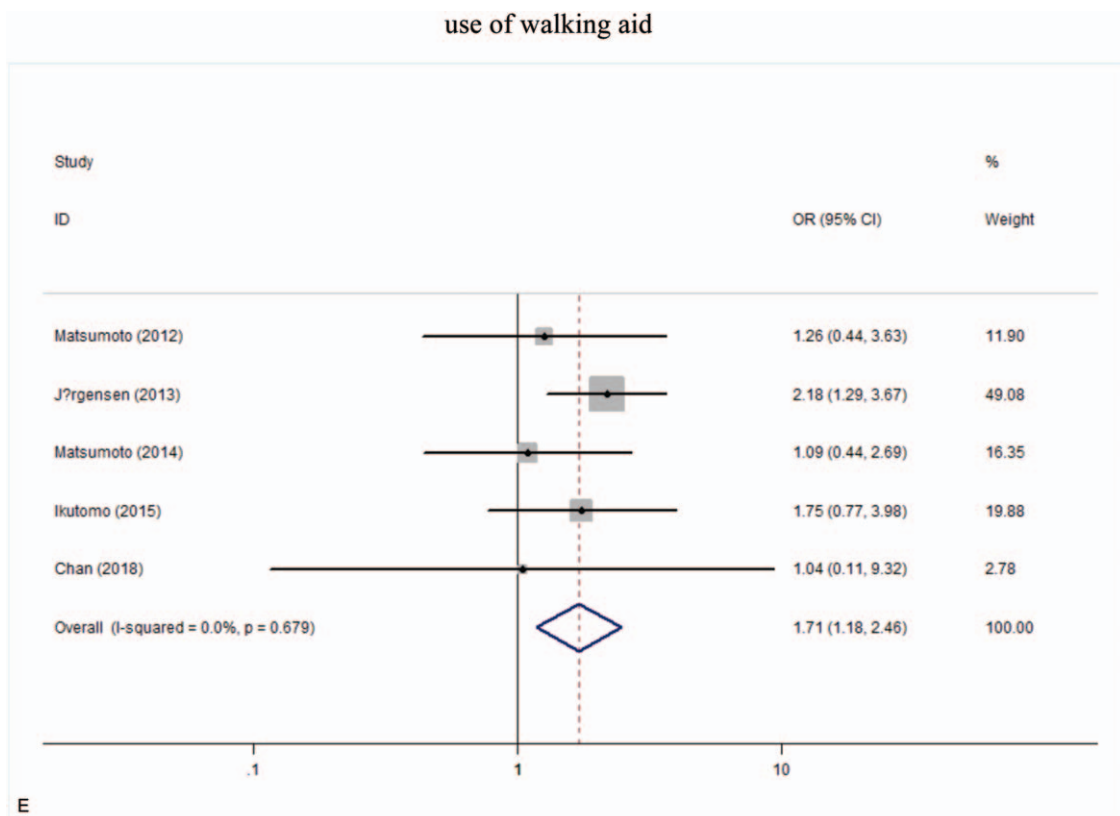


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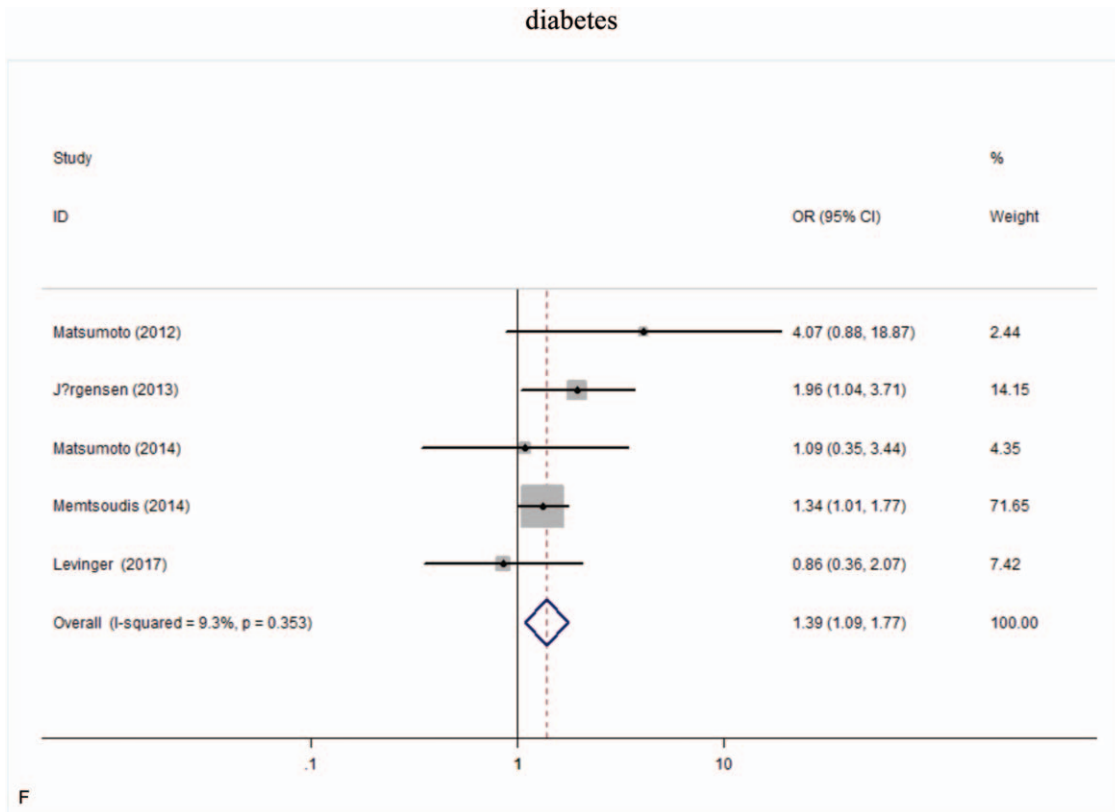


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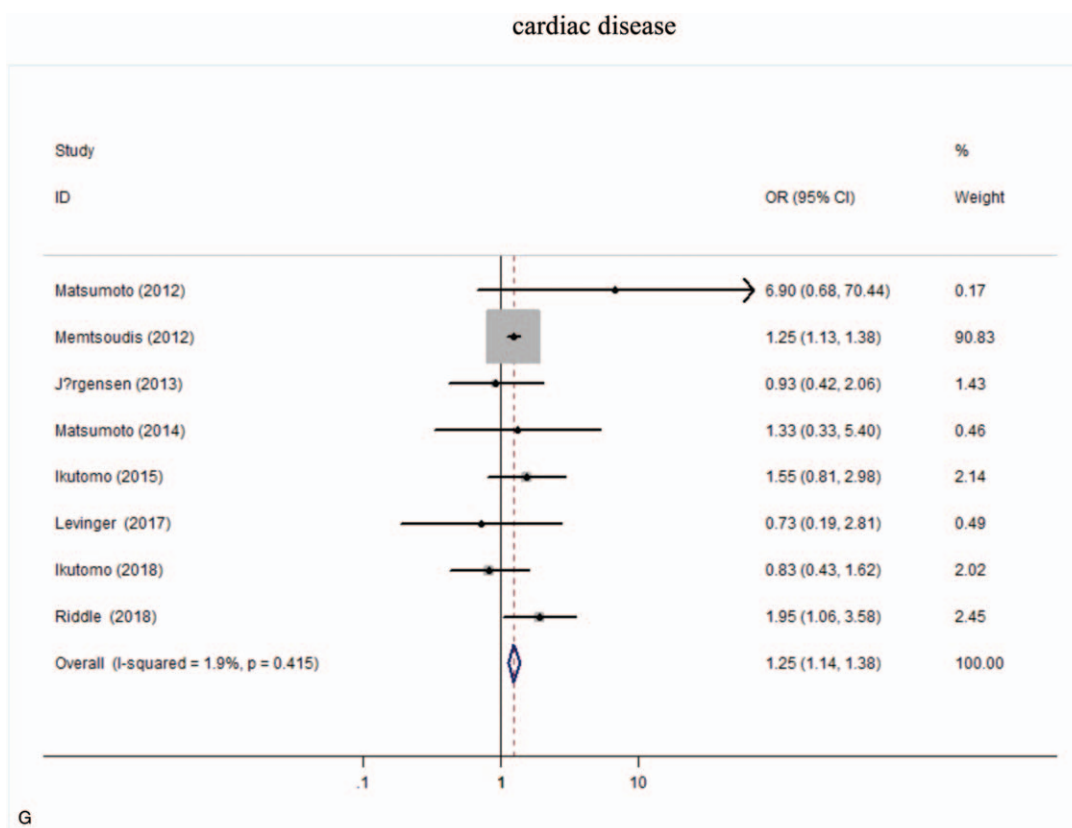


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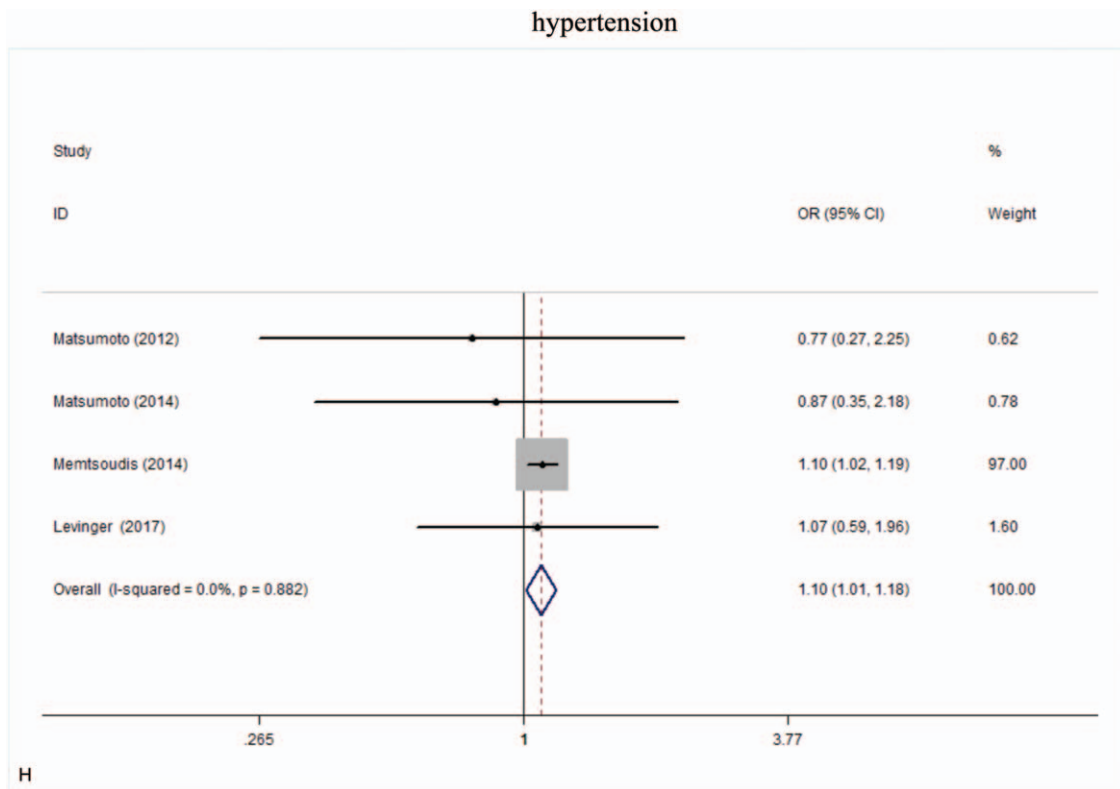


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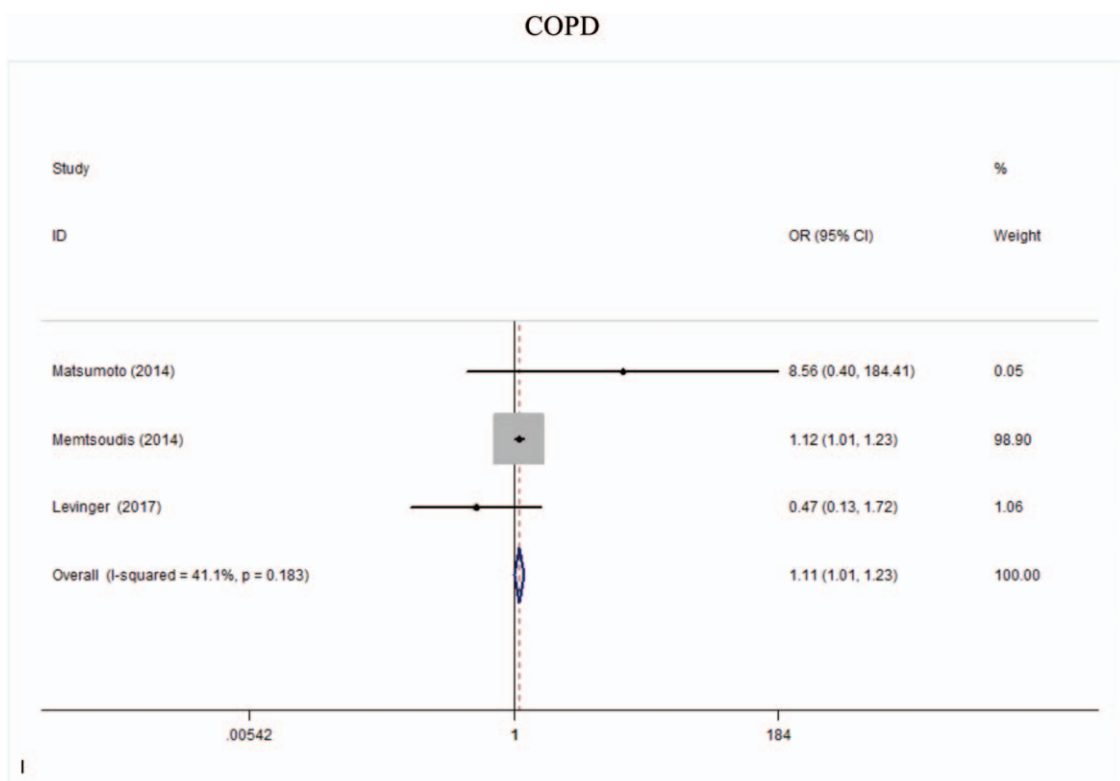


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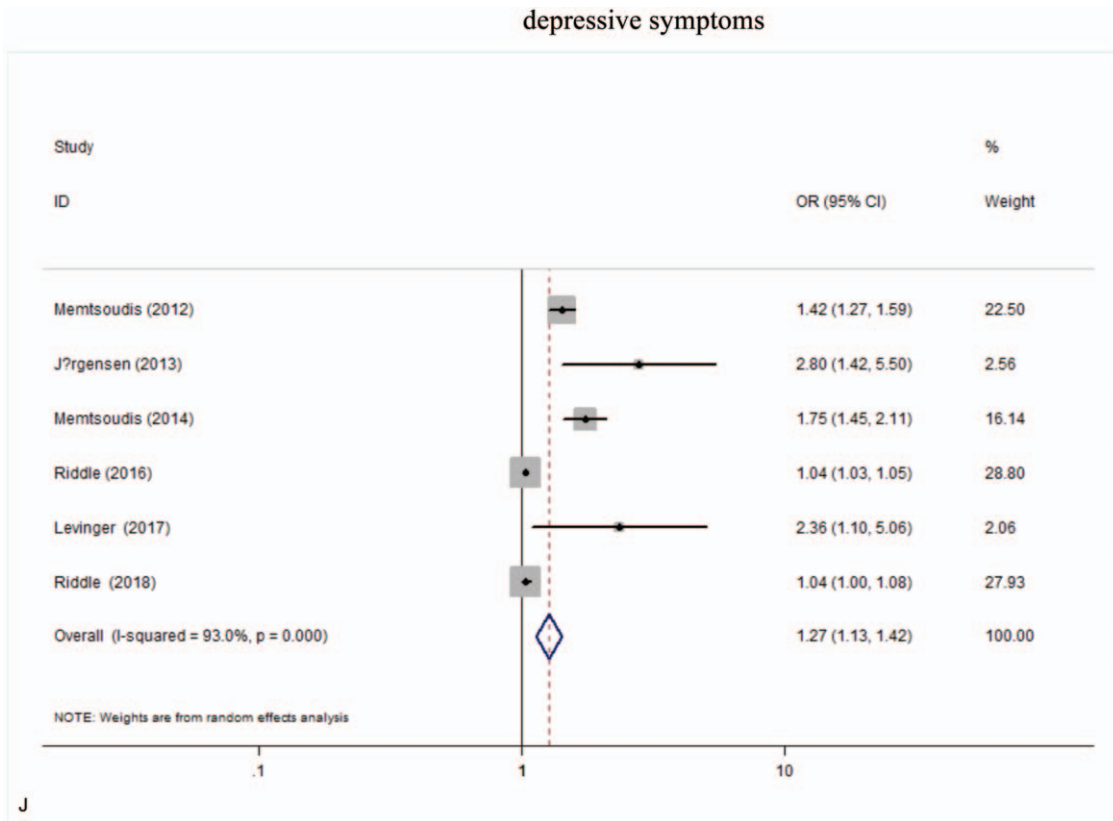


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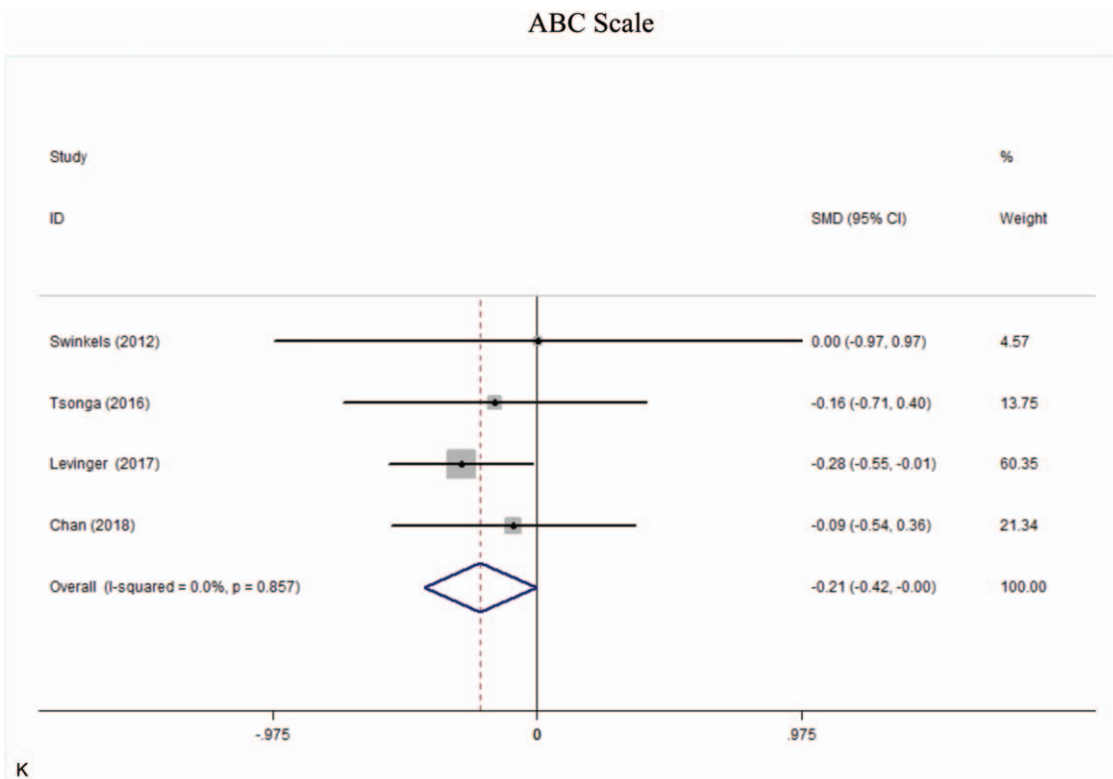


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Table 2
Detailed data on potential risk factors for patient falls after total joint arthroplasty and the outcomes of meta-analysis.

Potential risks	No of studies	Pooled OR or SMDs	LL95% CI	UL 95% CI	P value	Q-test for heterogeneity (P)	I^2 (%)
Age	10	1.05	1.01	1.09	.006 ^b	<0.001	85.70
Femal	8	1.61	1.36	1.91	<.001 ^a	0.510	0.00
BMI	8	-0.01	-0.13	0.11	.870 ^a	0.334	12.40
Overweight (BMI≥25kg/m ²)	3	1.18	1.08	1.28	<.001 ^a	0.148	47.70
Falls history	7	3.56	1.95	6.47	<.001 ^b	<0.001	79.90
Walking aid	5	1.71	1.18	2.46	.004 ^a	0.679	0.00
Diabetes	5	1.39	1.09	1.77	.007 ^a	0.353	9.30
Cardiac disease	8	1.25	1.14	1.38	<.001 ^a	0.415	1.90
Hypertension	4	1.10	1.01	1.18	.002 ^a	0.882	0.00
Depressive symptoms	6	1.27	1.13	1.42	<.001 ^b	<0.001	93.00
COPD	3	1.11	1.01	1.23	.003 ^a	0.183	41.10
Range of flexion and extension	2	-0.28	-0.62	0.06	.104 ^a	0.172	46.50
Sf-36PCS	2	-0.03	-0.27	0.21	.818 ^a	0.878	0.00
Sf-36MCS	2	-0.07	-0.31	0.17	.551 ^a	0.452	0.00
ABC Scale	4	-0.21	-0.42	0.00	.049 ^a	0.857	0.00

^a Fixed-effects model was performed.

^b Fandom-effects model was performed.

^c I^2 statistic was defined as the proportion of heterogeneity not due to chance or random error.

ABC Scale = Activities Balance Confidence Scale, BMI = body mass index, CI = confidence interval, COPD = Chronic Obstructive Pulmonary Disease, LL = lower limit, OR = odds ratio, Sf-36MCS = SF-36v2 Mental component score, Sf-36PCS = SF-36v2 Physical component score, SMDs = standardized mean differences, UL = upper limit.

clinicians pre- or postoperatively to reduce fall risk and subsequent injury in these patients.

Falls are common in the aged with potential severe consequences.^[30,35,36] Early and persistent muscle loss occurs after TJA,^[34] and as poor walking ability and impaired balance is associated with falling,^[23,32] Patients could be at increased risk of falling within the first months of these surgeries. Hence there is concern that early mobilization could potentially further increase the risk of falls after discharge,^[31] on the other hand, a faster return to daily life could result in a number of falls being related to increased level of activity rather than the surgery. Patient suffering from a fall were on average older, with 3.2 years older

than that in non-fallers groups in this study. Thus, suggested that age-related factors such as impaired reflexes, reduced motor strength, proprioceptive loss, and balance may play a role.^[22] Chan et al^[23] explained the relationship between proprioception and falls, indicating deficits in knee proprioception, coupled with age-related declines in somatosensory function and vestibular, may challenge the ability to effectively reweight information from different sensory subsystems that maintain body equilibrium, thereby increasing the fall risk in individuals with TKA.^[37,38] There are a multitude of deficits in physical function specific to TJA, such as joint pain, impairment in hip and knee proprioception, and balance, which may further contribute to

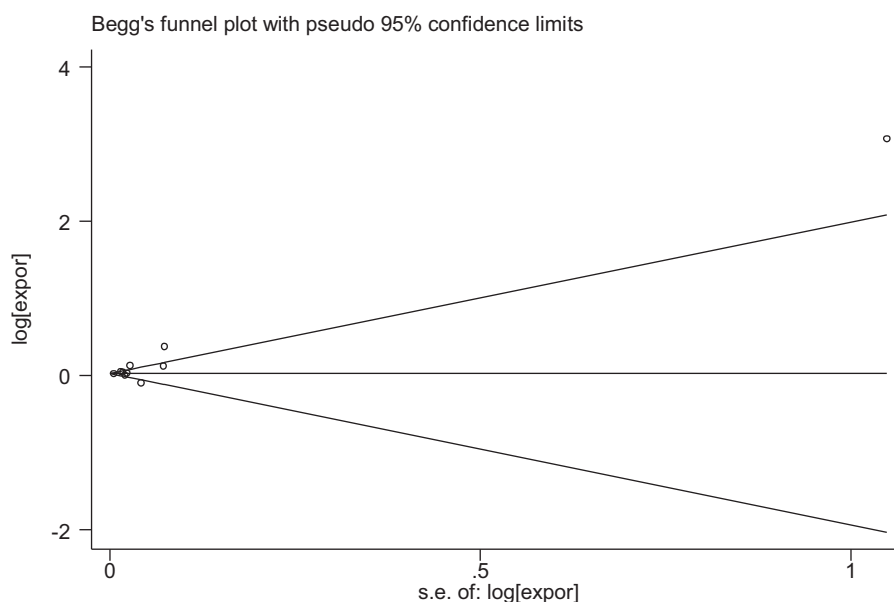


Figure 4. Begg's funnel plot for publication bias (with 95% pseudo confidence limits) of the observational studies that investigated no age differences between fallers and non-fallers after lower extremity joint replacement ($P = .210$).

falls. Moreover, the relationship between muscle weakness and falls is probably modified by multiple characteristics of the individual, job, and environment^[39]. Tai chi is an ancient Chinese practice focused on flexibility and whole-body coordination, this practice concentrating on movement, meditation and breathing, and paying attention to exteroceptive and proprioceptive cues to promote harmonized motion in space. Tai Chi has popular in China for several centuries, Tai Chi is of great significance to improving balance-control and flexibility in geriatric persons, suggesting a protective function against falls.

Female is probably more at risk of lowered bone mineral density due to menopause compared to male, which can justify the discrepancy between falls and fractures in men and women.^[40] There were many physiological characteristics for postmenopausal women, such as somatosensory retardation, mineral deficiencies and autonomic nervous dysfunction, meanwhile the risk of cardiovascular and cerebrovascular diseases and cerebellar function degeneration also increase the risk of falls for elderly women. Falls in the post-menopausal period can have very severe consequences ranging from fractures to diminished quality of life.^[41]

Morbidly obese patients may achieve similar pain relief, range of movement and stability, they are likely to remain more functionally impaired following TKA, with limitation of walking distance, ability to climb stairs and greater dependence on walking aids.^[42] An explanation why overweight was a risk factor for a post-TJA fall may include poorer pre-operative function, a mechanical effect of increased load, increased joint stiffness and difficulty walking.^[43,42] At the same time, it is believed that being overweight will reduce a woman's static balance.

Elderly patients with the history of fall may experience diminished level of activity and function as well as distressing signs of depression.^[44] On the other hand, increased risk of fall is associated with diminished mobility in response to lack of physical activity and senescence.^[45] However, some studies stated that experience of fall alone cannot limit physical activity and predict fall effectively.^[46] There are a strong support for establishing the use of the ABC scale as a predictive tool for correctly identifying elderly individuals more susceptible to falls.^[47–49] This would allow health care professionals to screen those with a substantial risk of falling and enroll them in a fall prevention training program.

Comorbidities are common in the elderly with lower limb OA and following joint replacement surgery, and are considered higher than the similar age asymptomatic counterparts.^[50] Comorbidities are associated with frailty which in turn can result in greater risk of falling.^[51–54] Prevalence of fall increases with increased number of chronic diseases, and chronic diseases are an important predictor in the elderly. The comorbidities through direct and indirect effects such as weakness of muscular power, reduced physical activity, and balance impairment cause increased risk of fall.^[55] With respect to hypertension, there are several potential linking mechanisms to falls related to both the condition itself and treatment side effects known to induce orthostatic hypotension.^[56] Older adults who have hypertension often combined with cardiovascular and cerebrovascular disease, cerebral artery blood supply insufficiency which will cause vertigo and other conditions. Anti-hypertensive medication and COPD were both associated with increased fall risk.^[57,58] Older diabetic patients are characterized by a number of comorbidities and functional impairments predisposing to gait abnormalities

and lower-extremity weakness,^[59] therefore, compared to their counterparts without diabetes, diabetic patients might be less able to buffer and compensate for the psychological and pathophysiological factors associated with chronic pain including reflex inhibition, fear of falling, joint instability, and reduced attention. Advanced age has a direct relationship with severity of depression symptoms in the elderly, as older individuals had more symptoms of depression compared to the others. Type of psychotropic medications might contribute to increased risk of falling in people following TJA; however, this requires further investigations with a larger sample size.

4.1. Strengths and limitations of this study

This is by far the first study to quantitatively summarize the risk factors of falls after TJA in elderly patients.

Some studies might choose not to report insignificant results or results of no interest. Hence, our overall effect may be somewhat an overestimate. The measurements of various risk factors differed from each other, and follow-up periods ranged widely from several months to several years. Nevertheless, the 2 reviewers evaluated the identified studies independently and any disagreement was resolved by discussion and consensus.

Author contributions

Data curation: Hao Liu.

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Methodology: Yang Liu, Wenyuan Wu.

Software: Xintao Wu.

Writing – original draft: Yanjiang Yang.

Writing – review & editing: Yang Liu.

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