SYSTEMATIC REVIEW

Risk Factors Associated With Fragility Fracture Among Older Adults With Fragility Fracture: A Systematic Review

Nur Suraya Abd Kahar[1,2], Chua Siew Kuan[1], Devinder K.A Singh[3,4], Sabarul Afian Mokhtar[5]

[1] Center for Physiotherapy Studies, Faculty of Health Sciences, Universiti Teknologi MARA Selangor, Puncak Alam Campus, 42300 Puncak Alam Selangor Malaysia
[2] Physiotherapy Department, Perak Community Specialist Hospital, 277 Jalan Raja Permaisuri Bainun, 30250 Ipoh, Perak
[3] Universiti Kebangsaan Malaysia, Faculty of Health Sciences, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia
[4] Physiotherapy Programme, Centre for Healthy Ageing and Wellness, Faculty of Health Sciences, Universiti Kebangsaan Malaysia.
[5] Department of Orthopedics, UKM Medical Centre, Jalan Yaacob Latiff, Bandar Tun Razak, Cheras, 56000 KL, Malaysia

ABSTRACT

Aim: To investigate risk factors of fragility fractures among older people. **Data Sources:** The electronic databases employed were PubMed, Science Direct, and Google Scholar from 2016 to December 2021. **Review Method:** The methodological quality of the studies was assessed using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-sectional study. Two independent reviewers screened total 147 articles. **Results:** Twelve studies were finally included in this review that consisted of 7 cross sectional, 2 longitudinal and 3 cohort studies. Six studies were of good quality and six were fair. Studies that were of good quality showed that physical performance, muscle strength, and falls due to balance impairment were associated with an increased of fragility fractures. While the results for sarcopenia status were uncertain. **Conclusion:** This review suggests that physical functional related factors were main contributors to the risk of fragility fracture among older people. Lack of research in this area warrants more studies to be carried out in the future.
Malaysian Journal of Medicine and Health Sciences (2022) 18(SUPP15): 318-326. doi:10.47836/mjmhs18.s15.44

Keywords: Fragility fracture, Hand grip strength, Muscle strength, Physical performance, Sarcopenia

Corresponding Author:
Chua Siew Kuan, PhD
Email: chuasiewkuah@uitm.edu.my
Tel: +603-3258 4492

INTRODUCTION

Fragility fracture is defined as fractures that are as a result from mechanical forces known as low-energy trauma (1).The incidence of fragility fracture increases each year where in 2010, estimated 158 million individuals were estimated to have high risk of fracture and this is likely to double by year 2050 (2). This increase trend of fractures are expected to rise in line with life expectancy. A fragility fracture leads to loss of function and mobility, psychological issues such as distress and anxiety due to loss of independence (1, 3-5). There was an increase in the number of fatalities in the year following a fracture incidence among older people (6). In addition, combined fracture and frailty is an increasing public health concern among older population (7, 8) with increased indirect socioeconomic costs worldwide (9).

Multiple factors contribute to the development of fragility fractures in older adults (10). With respect to physical factors, physical performance and muscle strength was known to be associated with increased risk of fragility fractures among older people (11). Low physical performance (PP) measured by endurance, balance, gait speed and muscle strength were associated with an increased risk of fragility fracture of hip among elderly men (9). Despite decline in physical performance, namely endurance and balance, predisposed to risk of falls and fractures, increase the susceptibility to a limitation in mobility and severe disabilities among older people (12), falls resulting from reduced muscle strength and mass, and balance also increase incidence of fractures among older people (11, 13). Reserved physical performance is the key contributor to late-life mobility and independence (14).

As a fracture imposes a huge demand on medical expenses for its association with series of adverse events such as recurrent fractures, mortality, as well as higher financial and social cost. Therefore, there is a need to have an effective primary and secondary prevention strategies, to reduce incidence of fragility fracture among older people. Therefore the aim of this research

is to examine the physical factors of fragility fracture risk among older people.

METHODOLOGY

Identification of studies

We identified peer-reviewed literature published related to the risk of factors for fragility fracture which is physical factors including physical performance, muscle strength, falls incidence, balance and sarcopenia status in elderly. The literatures were identified using electronic databases such as PubMed, Science Direct and Google Scholar, from the year 2016 to December 2021 including cross sectional, longitudinal or cohort study. Truncation of words that provides variations of a search term and Boolean terms was used to attain relation between keywords in developing a logical phrase within the database that followed population, exposure, and outcome to maximize and focus our search strategy. The literature search keywords are 'fragility fracture' AND 'falls' OR "Balance" OR 'sarcopenia' OR 'physical performance OR 'muscle strength. We included older people aged of 55 years old and above as the population of interest, physical factors of fragility fracture as exposure and fragility fracture as the outcome. This review also adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for conducting and reporting systematic reviews.

Selection of studies

We included articles, which investigated risk factors related to fragility fracture in elderly including physical performance, muscle strength, falls incidence, balance and sarcopenia status. Mendeley software was utilized to screen all the published sources acquired from different databases. Research studies operated in humans and published in English are qualified for this study. Eligibility of research studies are chosen based on the following criteria: (1) full-text article; (2) older adults 55 years old and above; (3) with one or more fragility fracture. Research studies obtained from conference abstracts, reviews, book chapters and letters were excluded from the review. Using the above selection criteria, two authors (NS and CS) independently screened all papers retrieved that is titles and/or abstracts of the identified literature. The full article was assessed by both reviewers (NS and CS), and consensus was reached through discussion or agreement with a third reviewer (DK), if required. We conducted a forward and reverse citation search of included papers.

Data Extraction

The selected articles enclosed in this study are entirely associated with the objective, which is to find out the physical risks factor for fragility fracture among older individuals. The essential characteristics extracted from the study includes sample size and the study population, study design, age, participant characteristics, fragility fracture definition, methodology, and study results.

Quality Assessment and Risk of Bias (RoB)

The methodological quality was assessed using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-sectional (15). The NIH quality tools consists of 14 questions in total with three options for answer; 1=yes, 0=no, and other (N/A=not applicable N/R=not reported, CD=cannot determine). Quality of studies were graded as "good", "fair" or "poor" (3). The risk of bias of the selected studies were thought to be inversely related to the quality of the research. A good quality research thought to have a low risk of bias (ROB), a fair-quality study has moderate ROB while a poor-quality study to have a high ROB (1). Table I shows the quality of the studies using the National Institutes of Health Quality Assessment Tool for Observational Cohort and Cross-sectional and the risk of bias (ROB) for each study.

RESULTS

Flow of studies in the review

Initially, a total of 147 publications were identified from all the databases. 15 studies were excluded due to duplicate articles, and 78 publications were excluded as the papers did not meet the inclusion criteria. A total of 54 full text articles were reviewed for eligibility, 23 studies were excluded as they were book chapters and review articles and another 19 studies were excluded as the participants consisted of younger to older peoples. A total of 12 studies were selected for this systematic review (Figure 1). Six studies were rated as good quality (16, 18, 22-24, 26) and another six rated as fair quality (17, 19- 21,25,27).

Characteristic of included studies

A total of 12737 older individuals participated in all studies where the majority of the participants were women (F=7753, M=4984) with a mean age ranged of 60 and 90 years old. Among the 12 studies, two studies involved elderly women subjects only. The studies were conducted in seven countries, which were China, Japan, Malaysia, Chile, Norway, Australia, and Canada. There were variations in the physical risks of fragility reported in each study as well as the outcome measures carried out in the studies. Table II summarizes the study characteristics included in this study comprising of study design, and the participants' characteristics.

Risk factors of fragility fracture

Table III showed the risk factor investigated as well as the outcome measures applied in all of the studies included in this systematic review. All studies (N=12) investigated physical factors, which are physical performance (balance, gait speed, endurance and flexibility), muscle strength (hand-grip, lower limb/Quadriceps strength. back strength), falls history, and sarcopenia status as a risk of fragility fracture in elderly populations. As shown in the Table IV, all of the studies were using different types of outcome measures for each variables

Table I. Quality Assessment and risk of bias for the selected Studies.

Study	National Institutes of Health Quality Assessment Tool for Observational Cohort and Cross-sectional questions														Quality scoring	Quality Rating	Risk of bias (RoB)
Questions	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14			
Zhou et al. (2017)[cs]	yes	yes	yes	yes	no	yes	no	yes	yes	no	yes	no	N/A	No	8	Poor	High
Salech et al. (2021)	yes	yes	no	yes	yes	yes	yes	yes	yes	no	yes	no	yes	yes	11	Good	Low
Chua et al. (2020)[cs]	yes	yes	yes	yes	yes	yes	N/A	yes	yes	no	yes	no	N/A	yes	10	Good	Low
Alajlouni et al. (2020)[co]	yes	yes	yes	yes	no	yes	yes	yes	yes	no	yes	no	yes	yes	11	Good	low
Swigaard et al. (2020)[co]	yes	yes	yes	yes	yes	yes	yes	no	yes	no	yes	no	N/R	yes	10	Good	low
Arima et al. (2017)[cs]	yes	yes	yes	yes	no	yes	N/A	yes	yes	no	yes	no	N/A	yes	9	Fair	moderate
Zhou et al. (2021)[cs]	yes	yes	yes	no	yes	yes	no	yes	yes	no	yes	no	yes	yes	10	Good	low
Pham et al. (2016)[lo]	yes	no	yes	yes	yes	yes	yes	no	yes	yes	yes	no	yes	no	10	Good	low
Badrasawi et al. (2017)[lo]	yes	yes	yes	yes	yes	yes	no	yes	yes	no	no	no	N/A	yes	9	Fair	moderate
Song et al. (2017)[co]	yes	yes	no	yes	no	yes	no	yes	yes	no	yes	no	yes	yes	9	Fair	moderate
Kirk et al. (2020)[cs]	yes	yes	yes	no	yes	yes	N/A	yes	yes	no	yes	no	N/A	yes	9	Fair	moderate
Lim et al. (2020)[cs]	yes	yes	yes	yes	no	yes	N/A	yes	yes	no	yes	no	N/A	yes	9	Fair	moderate

NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies. Q1: Research question, Q2: Study population, Q3: Participation rate, Q4: Inclusion criteria, Q5: Sample size, Q6: Exposure prior to outcome, Q7: Sufficient timeframe, Q8: Different level of exposure, Q9: Exposure measure, Q10: Multiple exposure measurement, Q11: Outcome measure, Q12: Blinding of outcome assessor, Q13: Loss of follow, Q14: Potential confounding.
Cohort study[co] Cross-sectional study[cs] Longitudinal study[lo]

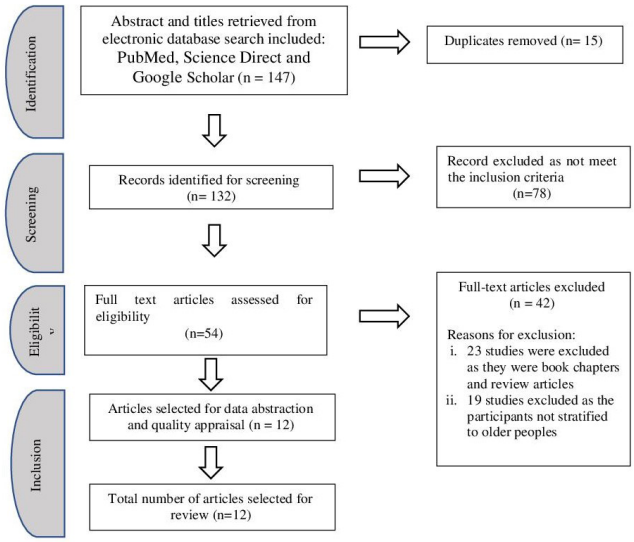

Figure 1: Prisma flow diagram of search strategy

investigated. Apparently, physical performance as well as muscle strength were risk factors that is highly investigated for its correlations with fragility fracture in elderly people.

Physical Performance

The assessment of physical performance can be further classified to balance, gait speed, endurance and flexibility. In this review, a total of nine studies were measuring physical performance of the participants. One of the studies assessed the participants' ability to cope with their daily living activities using the Activity of Daily Living (ADL) scale (Barthel Index) (16). While another study using the Rapid Assessment of Physical Activity (RAPA) questionnaire to assess the participants' level of physical performance (17).

Balance

A total of seven studies included in the review measured balance among its participants. Five studies (18-21) were using Timed Up and Go (TUG) outcome measure for measuring balance of the participants. Other studies measured balance employing the Biodex Balance System SD (17) and a static balance test (22) which consist of static tandem, semi-tandem and side by side test.

Gait speed

Gait speed was measured in eight studies in the review. Most of the studies were using different types of outcome measures for gait speed assessment. The measurement included GAITRite instrument (19), 6-meter distance walking test in four studies (16, 18, 21,23), normal and rapid pace gait speed test (20), 2.44-meter walking speed test (22) and 3-meter walking test (24).

Endurance

One study employed the 2-minute step test to investigate the endurance level as a factor for fragility (20).

Flexibility

A total of two studies investigated flexibility of the participants. One study used sit and reach test and the back scratch test (20), while another study used functional reach test in order to measure the flexibility among participants (23).

Muscle strength

Muscle strength was measured in ten of the studies, comprising hand-grip strength, lower limb strength, back muscle strength as well as respiratory muscle strength. These studies were using different types of outcomes measure for investigating muscle strength among the older people. Five studies were using the hand-held Jamar dynamometer to measure the dominant hand grip strength (19, 21-22, 24-25). In another study, the grip strength of the non-dominant hand was measured using the Martin Vigorimeter (26), While one study did not state the tool for hand grip strength measure (20).

Table II: Study design and participants characteristics

Author and year	Study design	Sample size	Gender		Inclusion criteria	
			Male	Female	Age	Study Population
Zhou et al. (2021)	Cross sectional study	N=300	187	113	≥ 80	Patients from the Outpatients Department of Geriatrics of Beijing Tongren Hospital
Salech et al. (2021)	Cross sectional study	N=1119	351	768	≥60	Community-dwelling people living in Chile
Chua et al. (2020)	Cross-sectional study	N=50	0	50	≥ 55	Attending patients (female) orthopaedic clinic, Hospital Canselor Tuanku Muhriz, Universiti Kebangsaan Malaysia Able to walk and independent in activities of daily living
Arima et al. (2017)	Cross-sectional study	N= 586	0	586	60–89	Community-dwelling Japanese women who had participated in the Hizen-Oshima Study
Zhou et al. (2017)	Cross sectional study	N=175	114	61	≥ 80	Patients from the Outpatients Department of Geriatrics of Beijing Tongren Hospital Could completely or basically maintain activity daily life (ADL score ≥ 75 points)
Kirk et al. (2020)	Cross-sectional study	N=484	147	337	≥ 65	community-dwelling older adults from western Melbourne, Victoria, Australia First database: 65 years old above, able to ambulate independently and no cognitive impairment Second database: Community-dwelling from Sarcopenia: Biological Environmental and risk factors in older adults (SEBA) study.
Lim et al. (2020)	Cross-sectional study	N=147	32	115	≥ 65	Attending patients who had undergone surgery for fragility HF at Seoul National University Bundang Hospital, Chung-Ang University Hospital, or Jeju National University Hospital from August 2016 to December 2018
Alajlouni et al. (2020)	Cohort study	N=1251	440	811	≥ 60	Community-dwelling women and men residing in the regional city of Dubbo
Swgaard et al. (2020)	Cohort study	N=6893	2891	4002	≥55	Elderly participants from Tromsw Study longitudinal population-based
Song et al. (2017)	Cohort study	N=50	17	33	≥ 65	50 ambulatory community- dwelling volunteers recruited via poster advertisements Able to ambulate independently
Pham et al. (2016)	Longitudinal study	N=761	595	1066	≥ 60	Participants who were participating in the Dubbo Osteoporosis Epidemiology Study
Badrasawi et al.(2017)	Longitudinal study	N=473	210	263	≥ 60	Participants from 10 different areas in the Klang Valley of Malaysia No known terminal or mental illnesses

Table III: Physical risk factors and outcome measure used in each study

Author(year)/ Variables	Physical performance				Muscle strength				Sarcopenia status	Falls history (Yes/No)
	Balance	Gait speed	Flexibility	Endurance	Hand grip strength	Lower limb/Quads	Back strength	Respiratory muscle		
Lim et al. (2020)					Jamar dynamometer				Bioelectrical Impedance Analysis	Yes
Kirk et al. (2020)	-TUG -Four square step test	GAITRite instrument			Jamar dynamometer				EWGSOP2	
Song et al. (2017)	The Biodex Balance System SD									Yes
	Rapid Assessment of Physical Activity(RAPA)questionnaire									
Badrasawi et al. (2017)	TUG	-rapid pace gait speed test	-seat and reach -back scratch	2-min step test	not mentioned	Chair stand time		Peak expiratory flow test		
Pham et al. (2016)						Horizontal Pocket Balance spring scale				Yes
Zhou et al. (2017)	TUG			6 mins walk test	Jamar dynamometer	Chair stand time				Fall risk assessment (FRA)
Arima et al. (2017)		-6-meter walk	-functional reach test			Chair stand time				
Swgaard et al. (2020)					-Martin Vigorimeter					
Alajlouni et al. (2020)	TUG	6meter walk test				-5x Sit to stand -Horizontal Pocket Balance spring scale				
Chua et al. (2020)	standing balance (static)	2.44m walking speed			Jamar dynamometer	5x sits to stand	Load cell system			Yes
Salech et al. (2021)		3-meter walking			Jamar dynamometer					Yes
Zhou et al. (2021)	TUG	6-meter walk test	Activity of Daily Living scale (Barthel Index)							Yes

TUG = Timed Up and Go test; HGS = Hand grip strength

Table IV: Data tabulation of results for each study in the review

Author and year	Variables investigated				Results
	Physical Performance	Muscle strength	Sarcopenia status	Falls history (yes/no)	
Zhou et al. (2021)	-TUG -6-meter walk test -Activity of Daily Living (Barthel Index)			yes	People who were older than 80 years old, outdoor activities of < 30 min/day, walking speed of < 0.8 m/s, and people with a TUG result of > 12 s were more likely to have falls Falls significantly correlated with fragility fractures Walking speed negatively correlated with fragility fractures,
Salech et al. (2021)	3-meter walking	-HGS		yes	The risk of falls higher in osteo-sarcopenic patients than in those without the condition Fracture risk was also higher among osteo-sarcopenic patients
Chua et al. (2020)	-static standing balance -2.44m walking speed	-HGS -5xSTS -Back Extensor		yes	Lower body function (SPPB score) have a lesser effect compared to muscle strength and body mass on BMD and fracture risk
Alajlouni et al. (2020)	-TUG -6-Meter walking	- 5xSTS -Horizontal Pocket Balance spring scale (Quadriceps)			QS (≤18 kg/m), TGUG (>8 s), 5xSTS time (≥14.5 s), and GS (≤0.8 m/s) were all associated with a 2- to 3-fold increase in fracture risk in elderly
Swgaard et al. (2020)		-Martin Vigorimeter			In both genders, the increased hazard ratio per 1 SD reduced grip strength was statistically significant to increase risk of fracture
Arima et al. (2017)	-6meter walk -Functional reach test	Chair stand time			Women with vertebral compression fractures had significantly poorer physical performance (slower walking speed, longer chair stand time and shorter functional reach)
Zhou et al. (2017)	-TUG -6-meter walk	-HGS -Chair stand ime		Fall risk assessment	Increase in the overall prevalence of fragility fractures in the population was related to the history of fall after 80 years old and the increase in the faer of falls FRA scores
Pham et al. (2016)		-Horizontal Pocket Balance spring scale (Quadriceps)		yes	Skeletal muscle strength (quadriceps strength) declined with advancing age in both women and men This reduction was associated with an increased risk of fracture in both sex Muscle weakness increases the risk of falls Falls that occur within the previous 12 months increases the risk of fracture.
Badrasawi et al. (2017)	-TUG -Rapid pace gait Set and reach test -2min step test	-HGS -Chair stand time -Peak expiratory flow			Rapid pace gait speed reported to be strongly related to frailty
Song et al. (2017)	-The Biodex Balance System -Rapid Assessment of Physical Activity (RAPA) questionnaire			yes	No significant relationship between balance and age, BMI, the FRAX risk of major osteoporotic fracture, or FRAX risk of hip fracture Activity level did not have a significant relationship with age, BMI, FRAX osteoporotic fracture score, FRAX hip fracture score for males, females, and both genders combined.
Kirk et al. (2020)	-TUG -4 square step test -GAITRite instrument	HGS	EWGSOP2		Prevalence of fragility fractures was significantly higher in those with confirmed sarcopenia Independent components of sarcopenia (ALM, handgrip strength and gait speed) increased the likelihood of osteoporosis fracture
Lim et al. (2020)		HGS	BIA	yes	Sarcopenia was correlated with increased risk of fragile falls

BIA= Bioelectrical Impedance Analysis TUG= Time up and Go, HGS= Hand Grip strength, 5XSTS= 5times sit to stand, EWGSOP2= European Working Group on Sarcopenia in Older People

The lower limb strength of the participants was measured using the chair stand time (20-21, 27), 5 times sit to stand (18, 22) and using the horizontal Pocket Balance spring scale in order to measure the maximal isometric quadriceps muscle contraction (18, 28). In this review, one study using a load cell system to measure back extensor muscle strength in a prone position (22).

Sarcopenia

There were two studies that measured the sarcopenia status in older people (19, 25). A study used the European Working Group on sarcopenia in older people (EWGSOP2) cut-points for identifying the participants with sarcopenia (19). While another study employed the tetrapolar bioelectrical impedance analysis (BIA) system for the body composition of the participants (25).

Falls history

Altogether, a total of six studies included the fall history of the participants as one of the factors for fragility fracture (16-17, 21-22, 24, 28). Fall history of the participants was included inside the socio-demographic data.

DISCUSSION

This systematic review aimed to review the physical risk factors related to fragility fracture among older people. In this review, four variables namely physical performance, muscle strength, sarcopenia status and fall history were identified to be the physical risk factor of fragility fracture among elderly population.

Physical performance and muscle strength were shown to be the most contributing factor for fragility fracture, as reported by 10 out of 12 studies in this review. Decline in physical activity including reduction in balance, gait speed and flexibility found to be predictors for fragility fracture, leads to impaired functions and disability (27). The findings on the physical risk factor for fragility fracture were consistent among the studies. Older people

presented with higher Timed Up and Go (TUG) values and reduced gait speed were all significantly associated with increase in fracture risk in older people (18-20, 27). A higher prevalence of fragility fracture was reported in older people who lack an adequate physical activity level indicated by difficulty to push a table, performing house chores, inability to crouch down, climbing stairs and kneeling (23).

Physical activity level, which includes balance and endurance reported by previous study also shown association with increase in fragility fracture, thus reducing the quality of life among frailty elderly (25). In addition, a prospective cohort study consisting of post-menopausal women, reported that failure to maintain balance for 10 seconds during standing and walking for 100 meters reported to be factors of increase in risk of fragility fracture (14). A retrospective study reported that reduced physical activity in older people increased the risk of fragility fracture (29). Physical engagement plays a significant role in preventing fragility fracture in older people especially one that arises from osteoporosis and decline in muscle mass (29). This is none other than the fact that physical activity helps in preventing osteoporosis and loss in bone mass density (30).

A regular exercise consisting moderate activity, 30-60 minutes three times a week (31) has been shown to have an effect as it helps to improve muscle strength (32) mass and bone density (33) which reduced the likelihood of fragility fracture (30, 34-35). A weight bearing exercise also shown to be safe and effective in preventing falls as well as falls-related fracture in older people, specifically in women (36). Thus, highlighting the importance of physical activity in preventing fragility fracture in older population.

However, inconsistent result observed in the correlation between walking speed and fragility fracture. From this research, walking speed has shown to have no direct correlation with fragility fractures (16). Instead, reduced outdoor activities, reduced walking speed and increased TUG result were more likely to cause a new fall, which increase fragility fracture among elderly. In addition, a negative correlation between activity level and balance with fragility fracture was reported among older people (17). This inconsistent result was reported to be due to the small sample size of population included in the study (50 participants), thus causing limitations in obtaining a precise pictures for both of the factors in regards to fragility fracture (17). This in return suggests for more future research to be carried out in order to assess further association of fragility fracture with balance in older people.

Muscle strength, namely the hand-grip strength, lower limb strength and back muscle strength shown to be significant with increased risk of fragility fracture (18, 20, 22, 26-28). Reduced handgrip strength was reported to increase the risk of fragility fracture in both men and women (37). Grip strength also associated with more frailty markers in elderly men and women, including bone mineral density and osteoporosis which contributes to fracture in elderly population (22, 38). This finding was further supported by other studies (4, 9, 18, 23, 27, 39) which shown the correlation between muscle strength and fragility fracture among older people.

As people grows older, decline in muscle strength were highly susceptible. The rate of declination shown to be more dependent on age, which is older adults has higher rate of declination in muscle strength compared to younger adults and are prone to fracture (39). The European Working Group on Sarcopenia in Older People (EWGSOP2) stated that sarcopenia was characterized as a decline of skeletal muscle mass (men < 7.0 kg/m^2, women < 5.5 kg/m^2), reduced grip strength (men < 27 kg, women < 16 kg) and slower gait speed (men and women ≤ 0.8 m/s) (40). This review shows that decline in the muscle strength namely the hand-grip strength and gait speed were found to be the factors of sarcopenia, in which participants with sarcopenia are most likely to experience fragility fracture (19, 24-25).

Falls contributed as one of factor for fragility fracture among elderly. This review shown that elderly who have declined in muscle strength (28) and lower physical performance including balance and gait speed were more likely to experience falls incidents and increase risk of fragility fracture among older people (12). Reduced upper and lower limb strength, muscle endurance, poor limb flexibility and agility also reported to increase in falls incident (41) which leads to fracture and poor quality of life among older people. An increase in the prevalence of fragility fracture was related to history of fall after 80 years old and increase in fear of fall (16, 21). Falls that occur within 12 months, in return, lead to an increase risk in the fragility fracture of both sexes.

In addition, fragility fracture caused by falls was correlated with sarcopenia (25). The prospective studies observed that older people with sarcopenia had a higher risk of falls compared to non-sarcopenia people (37-38). This increased risk of falls in older people with sarcopenia was to be expected due to loss of the fast-twitch muscle fiber and motor neurons (39) as a result of decline in muscle mass with aging (42-43). Sarcopenia shown to be related to decline in muscle mass and strength, increasing the likelihood of fragility fracture caused by a fall. The lower limbs muscles act as a stabilizer, especially during walking and play a role as absorber during falls incident. Therefore, weakness of the lower limb muscles increases the chances of falls and fragility fracture among older people presenting with sarcopenia (25). In contrast, previous study reported there was no association between falls and the prevalence of fragility fracture among elderly (23). This conflict of findings could be attributed to fear of falling among elderly.

CONCLUSION

This systematic review suggests that physical factors namely physical performance (balance, gait speed, endurance and flexibility), muscle strength, sarcopenia status and history of falls contributed independently to increase fragility fracture risk in elderly. However, the correlation of sarcopenia as well as falls with fragility fracture were still unclear as there is limited study conducted to investigate its correlation with fragility fracture. This review may be useful to provide an early prevention and management strategies, especially by identifying the physical factors for fragility fracture among older people.

REFERENCES

1. National Institute for Health and Care Excellence NICE: Clinical Guideline [CG146] - Osteoporosis: assessing the risk of fragility fracture. 2012.
2. Odén A, McCloskey EV, Kanis JA, Harvey N, Johansson H. Burden of high fracture probability worldwide: secular increases 2010–2040. Osteoporosis International. 2015; 26:2243-8. doi: 10.1007/s00198-015-3154-6
3. Jung HJ, Park YS, Seo HY, Lee JC, An KC, Kim JH, et al. Quality of life in patients with osteoporotic vertebral compression fractures. Journal of Bone Metabolism. 2017; 24(3):187-96. doi: 10.11005/jbm.2017.24.3.187
4. Longo AB, Ward WE. PUFAs. Bone Mineral Density, and Fragility Fracture: Findings from Human Studies, Advances in Nutrition. 2016; 7(2): 299–312. doi:10.3945/an.115.009472
5. Talevski J, Sanders KM, Busija L, Beauchamp A, Duque G, Borgstrцm F, et al. Health service use and quality of life recovery 12 months following major osteoporotic fracture: latent class analyses of the International Costs and Utilities Related to Osteoporotic Fractures Study (ICUROS). Journal of Bone and Mineral Research. 2021;36(2):252-61. doi:10.1002/jbmr.4181
6. Monteagudo P, Cordellat A, Rold6n A, Pesce C, Blasco-Lafarga C. Assessing health-related quality of life in older adults: EuroQol five-dimensional questionnaire vs the short form health survey. Sport Mont. 2020; 18(2):117–20. doi:10.26773/smj.200609
7. Li PS, Hsieh CJ, Miao NF. A Study of Physical Activity, Frailty, and Health-Related Quality of Life among Community-Dwelling Older Adults in Taiwan. Journal of Nursing Research. 2020; 28(6):1–11. doi:10.1097/JNR.0000000000000402
8 Kojima G, Iliffe S, Jivraj S, Walters K. Association between frailty and quality of life among community-dwelling older people: a systematic review and meta-analysis. J Epidemiol Community Health. 2016;70(7):716-21. doi:10.1136/jech-2015-206717
9. Cawthon PM, Blackwell TL, Marshall LM, Fink HA, Kado DM, Ensrud KE, et al. Physical performance and radiographic and clinical vertebral fractures in older men. Journal of Bone and Mineral Research. 2014;29(9):2101-8. doi: 10.1002/jbmr.2239
10. Trajanoska K., Rivadeneira F. The genetic architecture of osteoporosis and fracture risk. Bone. 2019;126:2–10. doi:10.1016/j.bone.2019.04.005
11. Wong RM, Ho WT, Wai LS, Li W, Chau WW, Chow KH, et al. Fragility fractures and imminent fracture risk in Hong Kong: one of the cities with longest life expectancies. Archives of osteoporosis. 2019; 14(1):104. doi:10.1007/s11657-019-0648-4
12. Morita M, Takamura N, Kusano Y, Abe Y, Moji K, Takemoto T, et al. Relationship between falls and physical performance measures among community-dwelling elderly women in Japan. Aging Clin Exp Res. 2005; 17(3):211–6. doi:10.1007/BF03324599
13. Yoshimura N, Oka H, Muraki S, Akune T, Hirabayashi N, Matsuda S, et al. Reference values for hand grip strength, muscle mass, walking time, and one-leg standing time as indices for locomotive syndrome and associated disability: the second survey of the ROAD study. Journal of Orthopaedic Science. 2011;16(6):768-77. doi:10.1007/s00776-011-0160-1
14. Pahor M, Guralnik JM, Ambrosius WT, Blair S, Bonds DE, Church TS, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. JAMA. 2014;311(23):2387-96. doi:10.1001/jama.2014.5616
15. National Heart, Lung, and Blood Institute. Quality assessment tool for observational cohort and cross-sectional studies. Bethesda: National Institutes of Health, Department of Health and Human Services. 2014.
16. Zhou J, Liu B, Qin MZ, Liu JP. A prospective cohort study of the risk factors for new falls and fragility fractures in self-caring elderly patients aged 80 years and over. BMC geriatrics. 2021 ;21(1):1-9. doi:10.1186/s12877-021-02043-x
17. Song S, MacDermid JC, Grewal R. Corrigendum to "Risk Factors for Falls and Fragility Fractures in Community-Dwelling Seniors: A One-Year Prospective Study". International Scholarly Research Notices. 2017. doi:10.1155/2017/3814602
18. Alajlouni D, Bliuc D, Tran T, Eisman JA, Nguyen TV, Center JR. Decline in muscle strength and performance predicts fracture risk in elderly women and men. The Journal of Clinical Endocrinology & Metabolism. 2020;105(9):e3363-73. doi:10.1210/clinem/dgaa414.
19. Kirk B, Phu S, Brennan-Olsen SL, Bani Hassan E, Duque G. Associations between osteoporosis, the severity of sarcopenia and fragility fractures in community-dwelling older adults. Eur. Geriatr. Med. 2020;11:443-50. doi:10.1007/s41999-020-00301-6

20. Badrasawi M, Shahar S, Singh DK. Risk factors of frailty among multi-ethnic Malaysian older adults. International Journal of Gerontology. 2017;11(3):154-60. doi:10.1016/J.IJGE.2016.07.006
21. Zhou J, Qin MZ, Liu Q, Liu JP. Investigation and analysis of osteoporosis, falls, and fragility fractures in elderly people in the Beijing area: a study on the bone health status of elderly people≥ 80 years old with life self-care. Archives of osteoporosis. 2017;12(1):1-8. doi:10.1007/s11657-017-0408-2
22. Chua SK, Singh DK, Zubir K, Chua YY, Rajaratnam BS, Mokhtar SA. Relationship between muscle strength, physical performance, quality of life and bone mineral density among postmenopausal women at risk of osteoporotic fractures. Science, Engineering and Health Studies. 2020; 22:8-21.
23. Baccaro LF, Machado VD, Costa-Paiva L, Sousa MH, Osis MJ, Pinto-Neto AM. Factors associated with fragility fractures in women over 50 years of age: a population-based household survey. Revista Brasileira de Ginecologia e Obstetrнcia. 2013; 35:497-502. doi:10.1590/s0100-72032013001100004
24. Salech F, Marquez C, Lera L, Angel B, Saguez R, Albala C. Osteosarcopenia predicts falls, fractures, and mortality in Chilean community-dwelling older adults. Journal of the American Medical Directors Association. 2021;22(4):853-8. doi:10.1016/j.jamda.2020.07.032
25. Lim SK, Beom J, Lee SY, Kim BR, Chun SW, Lim JY, et al. Association between sarcopenia and fall characteristics in older adults with fragility hip fracture. Injury. 2020;51(11):2640-7. doi: 10.1016/j.injury.2020.08.031
26. Søgaard AJ, Magnus JH, Bjørnerem E, Holvik K, Ranhoff AH, Emaus N, et al. Grip strength in men and women aged 50–79 years is associated with non-vertebral osteoporotic fracture during 15 years follow-up: The Tromsш Study 1994–1995. Osteoporosis International. 2020 ;31(1):131-40. doi:10.1007/s00198-019-05191-4
27. Arima K, Abe Y, Nishimura T, Okabe T, Tomita Y, Mizukami S, et al. Association of vertebral compression fractures with physical performance measures among community-dwelling Japanese women aged 40 years and older. BMC musculoskeletal disorders. 2017;18(1):1-8. doi: 10.1186/s12891-017-1531-3
28. Pham HM, Nguyen ND, Center JR, Eisman JA, Nguyen TV. Contribution of quadriceps weakness to fragility fracture: a prospective study. Journal of Bone and Mineral Research. 2016;31(1):208-14. doi:10.1002/jbmr.2594
29. Meriläinen M, Oikarinen P, Mikkonen K, Kaakinen P. Predictors of Fragility Fractures and Osteoporosis Among People Over 50 Years Old-A Retrospective Cohort Study. International journal of orthopaedic and trauma nursing. 2020; 36:100709. doi:10.1016/j.ijotn.2019.100709
30. Määttä M. Assessment of Osteoporosis and Fracture Risk: Axial Transmission Ultrasound and Lifestyle-related Risk Factors. University of Oulu; 2012.
31. Simmonds BA, Hannam KJ, Fox KR, Tobias JH. An exploration of barriers and facilitators to older adults' participation in higher impact physical activity and bone health: a qualitative study. Osteoporosis International. 2016;27(3):979-87. doi:10.1007/s00198-015-3376-7
32. Papaioannou A, Morin S, Cheung AM, Atkinson S, Brown JP, Feldman S, et al. 2010 clinical practice guidelines for the diagnosis and management of osteoporosis in Canada: summary. Cmaj. 2010;182(17):1864-73. doi:10.1503/cmaj.100771
33. Mosti MP, Kaehler N, Stunes AK, Hoff J, Syversen U. Maximal strength training in postmenopausal women with osteoporosis or osteopenia. The Journal of Strength & Conditioning Research. 2013 ;27(10):2879-86. doi:10.1519/JSC.0b013e318280d4e2
34. Fletcher JA. Canadian academy of sport and exercise medicine position statement: osteoporosis and exercise. Clinical journal of sport medicine. 2013;23(5):333-8. doi:10.1097/JSM.0000000000000002
35. Palombaro KM, Black JD, Buchbinder R, Jette DU. Effectiveness of exercise for managing osteoporosis in women postmenopause. Physical therapy. 2013;93(8):1021-5. doi: 10.2522/ptj.20110476
36. Korpelainen R, Keinдnen-Kiukaanniemi S, Heikkinen J, Vддnдnen K, Korpelainen J. Effect of impact exercise on bone mineral density in elderly women with low BMD: a population-based randomized controlled 30-month intervention. Osteoporosis international. 2006;17(1):109-18. doi:10.1007/s00198-005-1924-2
37. Kärkkäinen M, Rikkonen T, Kruger H, Sirola J, Tuppurainen M, Salovaara K, et al. Association between functional capacity tests and fractures: an eight-year prospective population-based cohort study. Osteoporosis International. 2008;19(8):1203-10. doi:10.1007/s00198-008-0561-y
38. Nilwik R, Snijders T, Leenders M, Groen BB, van Kranenburg J, Verdijk LB, et al. The decline in skeletal muscle mass with aging is mainly attributed to a reduction in type II muscle fiber size. Experimental gerontology. 2013;48(5):492-8. doi:10.1016/j.exger.2013.02.012
39. Singh DK, Bailey M, Lee R. Decline in lumbar extensor muscle strength in older adults: correlation with age, gender and spine morphology. BMC musculoskeletal disorders. 2013;14(1):1-6. doi: 10.1186/1471-2474-14-215
40. Forrest KYZ, Williams AM, Leeds MJ, Robare JF, Bechard TJ. Patterns and correlates of grip strength in older Americans. Curr Aging Sci. 2018;11:63-70. doi:10.2174/1874609810666171116164000

41. Landi F, Liperoti R, Fusco D, Mastropaolo S, Quattrociocchi D, Proia A, et al. Sarcopenia and mortality among older nursing home residents. Journal of the American Medical Directors Association. 2012;13(2):121-6. doi:10.1016/j.jamda.2011.07.004
42. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age and ageing. 2019;48(1):16-31. doi:10.1093/ageing/afy169
43. Oliveira A, Vaz C. The role of sarcopenia in the risk of osteoporotic hip fracture. Clin Rheumatol. 2015; 34: 1673–80. doi:10.1007/s10067-015-2943-9