Review Article

Prognostic Factors of Hip Fracture in Elderly: A Systematic Review

Abstract

The hip fracture causes significant disabilities in many elderly people. Many studies around the world have identified various risk factors for the hip fracture. The aim of this study was to systematically investigate the risk factors of hip fractures. This study is a systematic review of risk factors for hip fractures. All published papers in English and Persian languages on patients in Iran and other countries between 2002 - 2022 were examined. The search strategy used keywords matching the mesh, including : predictors, hip fracture, and disability. Articles were selected from international databases (PubMed, Proquest ,Web of Sience, Scopus, Google scholar and Persian(Sid,Magiran), and the Newcastle Ottawa Scale was used to assess the risk of bias. The study has identified several factors that were significantly correlated with the risk of hip fracture, including age, cigarette and alcohol consumption, visual and hearing problems, low BMI levels, history of falling, weakness, and diseases such as stroke, cardiovascular disease, high blood pressure, arthritis, diabetes, dementia, Alzheimer's, Parkinson's, liver and kidney diseases, bone density, osteoporosis, vertebral fracture, and hyperthyroidism. However, the study did not find any significant correlations between the consumption of calcium and vitamin D, history of fractures, cognitive disorders, schizophrenia, and household income, and the risk of hip fracture. The results of this study reveal the determining role of some risk factors in hip fracture in older persons. Therefore, it is recommended that health policy makers provide the possibility of early intervention for some changeable factors.

Keywords: *Prognostic factors, hip Fracture, elderly, systematic review*

Khadijeh Kalan Farmanfarma[1], Soudabeh Yarmohammadi[1], Esmaeil Fakharian[2], Robbert J. Gobbens[3], Mehrdad Mahdian[1], Zahra Batooli[4], Mohammad-Sajjad Lotfi[5], Masoumeh Abedzadeh-Kalahroudi[6], Reza Fadaei Vatan[7], Gholamreza Reza Khosravi[1], Mohammad Reza Fazel[1], Mojtaba Sehat[8]

[1]Trauma Research Center, Kashan University of Medical Sciences, Kashan, Iran, [2]Trauma Research Center, Department of Neurosurgery, Kashan University of Medical Sciences, Kashan, IR Iran, [3]Faculty of Health, Sports and Social Work, Inholland University of Applied Sciences, Amsterdam, The Netherlands,

Address for correspondence:
Dr. Mojtaba Sehat, Trauma Research Center, Department of Community Medicine, Faculty of Medicine, Kashan University of Medical Sciences, Kashan, Iran. E-mail: mojtabasehat982@gmail.com

Introduction

Hip fracture is one of the most common causes of fractures in older persons. The annual mortality rate of older persons with hip fractures is reported between 14% and 36%.[1] With the increase in the number of elderly and life expectancy worldwide, especially in developing countries, such as Asian, African, South American, and Middle Eastern countries, the incidence of hip fractures is also increasing,[2,3] hence it is predicted that by 2050, the number of fractures will reach 6.3 million people.[4] The high incidence of hip fractures can be related to causes such as falls, social and lifestyle changes, bone density reduction, high prevalence of drug use, low levels of calcium and vitamin D, and reduced mobility of people.[5] Hip fracture in the elderly, called "the last fracture of life," has a strong effect on their quality of life and is accompanied by an increase in social and family burdens.[6] Due to the increase in the elderly population in the world, the present study was conducted to systematically investigate the factors affecting the incidence of hip fractures.

Method

The current study was conducted based on PRISMA standards.[7]

Search strategy and information sources

The study is a systematic review of risk factors in hip fracture incidence. All the papers published in both Persian and English languages, in the patient population of Iran and other countries, and domestic and foreign journals during the period of 2002–2022 were examined. The search strategy was the keywords matching the mesh, including:

(Predictor* OR Risk Factor* OR Causality* OR Risk Score* OR Prognostic OR "Health correlate" OR "Population at risk") AND (Hip *OR *Trochanteric* OR "neck of femur" OR "lower end of femur") AND (break* OR fracture*) AND Disability* OR "Disability Evaluation" OR Frailty* OR "Frailty Syndrome" OR Debility* OR imperfection* OR weakness* OR infirmity*

Articles were selected from international databases (PubMed, Proquest, Web of Science, Scopus, Google Scholar) and Persian (Sid, Magiran). It should be noted that the OR operator was used to connect synonyms and the AND operator was used to combine the obtained results.

How to cite this article: Kalan Farmanfarma K, Yarmohammadi S, Fakharian E, Gobbens RJ, Mahdian M, Batooli Z, *et al.* Prognostic factors of hip fracture in elderly: A systematic review. Int J Prev Med 2024;15:42.

Access this article online
Website: www.ijpvmjournal.net/www.ijpm.ir
DOI: 10.4103/ijpvm.ijpvm_169_23
Quick Response Code:

[4]*Social Determinants of Health (SDH)Research Center, Kashan University of Medical Sciences, Kashan, Iran,* [5]*Trauma Nursing Research Center, Faculty of Nursing and Midwifery, Kashan University of Medical Sciences, Kashan, Iran,* [6]*Trauma Nursing Research center Kashan University of Medical Sciences, Kashan, Iran,* [7]*Iranian Research Center on Ageing, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran,* [8]*MD, PhD in Epidemiology, Trauma Research Center, Department of Community Medicine, Faculty of Medicine, Kashan University of Medical Sciences, Kashan, Iran*

Study selection and eligibility criteria

The inclusion criteria comprised cross-sectional and cohort studies, case-control studies, and clinical trials. Studies lacking necessary and related information to the topic, as well as review studies, case studies, and letters to the editor, were excluded from the study. Finally, 17 papers entered the final stage. The full texts of the articles were reviewed.

Data collection process and risk of bias assessment

The abstracts and full texts of the articles were independently checked by two researchers (KFF and SYa) and the information in the checklist included the author's name, publication year, the study location, study type, age and gender of the subjects, sample size and risk factors. Re-review was done by the first researcher to increase the accuracy and validity of the information.

The Newcastle–Ottawa Scale (NOS) was employed in this systematic review to assess the quality of articles.[8] Scores of 7–9, 4–6, and 4 were classified as having a low, moderate, or high risk of bias, respectively [Table 1].

Results

Study selection and study characteristics

In the initial review, 1295 studies were found. After removing 710 duplicate articles and 315 unrelated articles, finally, 17 articles were reviewed [Figure 1]. The characteristics of the reviewed studies (including authors, publication year, the study country, type of study, sample size, gender, age, and risk factors) are presented in Table 2.

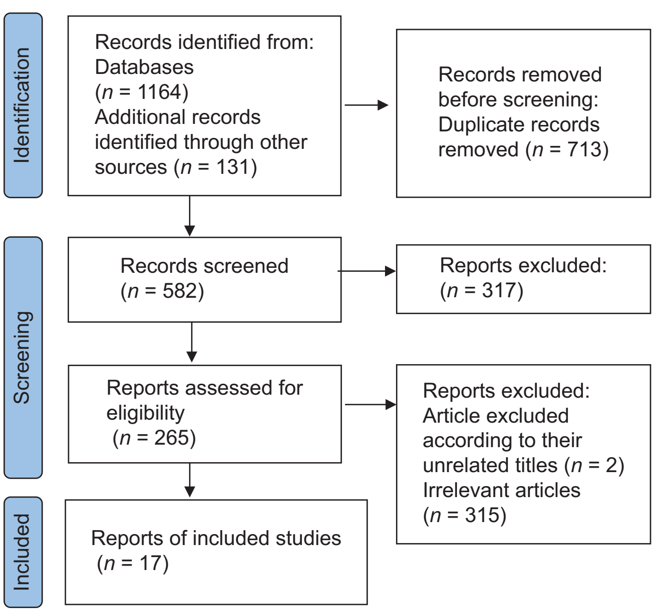

Figure 1: Flowchart of the included eligible studies in the systematic review

Results of individual studies

The results of the present study showed a significant correlation between different factors, for instance, sociodemographic factors (e.g., age, sex) lifestyle factors (e.g., cigarette and alcohol consumption), diseases (e.g., visual and hearing problems, low body mass index (BMI) levels, stroke, cardiovascular disease, high blood pressure, arthritis, diabetes, dementia, Alzheimer, Parkinson, liver and kidney diseases, bone density, osteoporosis, vertebral fracture, hyperthyroidism, hyponatremia, consume of corticosteroids), physical factors (e.g., grip strength, history of falling, weakness), social factors (e.g., death of a spouse, lack of dependence on others to move), and the risk of hip fracture. However, there was no significant correlation between the consumption of calcium and vitamin D, a history of fractures, cognitive disorders, schizophrenia, and household income, and the risk of hip fracture [Table 2].

Discussion

Gender and age

Table 2 shows that the relative risk of hip fracture in females was significantly higher than in males relative risk=(2.00 (95% CI: 1.13–3.53) and by increasing age, the risk of hip fracture increased significantly, RR = 4.17 (95% CI: 3.77–4.60). Studies have indicated that hip fractures in middle-aged and elderly women are about 90% more than in men, which can be caused by the decrease in estrogen levels in women after menopause, due to the decrease in bone density.[26,27]

Osteoporosis

The study indicates that osteoporosis had a significant relationship with the incidence of hip fracture OR= odds ratio odds ratio=1.35 (95% CI: 1.24–1.46) [Table 2]. Hip fracture is often associated with osteoporosis. A high incidence of fractures in people aged under 50 years can also be caused by osteoporosis.[28,29] Reports have shown that drug treatment of osteoporosis reduces the risk of hip fracture by 50–70%.[30,31]

Hypertension

As per this study, having high blood pressure increased the chance of hip fracture by 75% [Table 2]. The pathogenesis of osteoporosis-related fractures is based on two important

Table 1: The Newcastle Ottawa Scale for risk of bias assessment of the included studies

Study	Selection				Comparability	Outcome			Overall
Cohort	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Outcome (not present at the start)		Assessment of outcome	Adequacy of follow-up length	Adequacy of follow up	
Woo SH (2020)[9]	*		*	*	-/*		*	*	6
Ottenbacher KJ (2002)[10]	*	*	*	*	**	*	*	*	9
Walter LC (2003)[11]	*		*	*	-/*	*	*	*	7
Wainwright SA (2005)[12]	*	*	*	*	-/*	*	*	*	8
Alfaro-Acha A (2006)[13]	*		*	*	-/*	*	*	*	7
Nakamura K (2009)[14]	*		*	*	-/*	*	*	*	7
Barzilay JI (2013)[15]	*		*	*	-/*	*	*	*	7
Furuya T (2013)[16]	*		*	*	-/*	*	*	*	7
Sørensen HJ (2013)[18]	*	*	*	*	**	*	*		8
Lobo E, (2018)[19]	*		*	*	**	*	*	*	8
Wang HK (2014)[20]	*	*	*	*	**	*	*	*	9
Stenholm S (2015)[21]	*	*	*	*	**	*	*	*	9
Tal S (2015)[22]	*		*	*	*	*	*	*	7
Kim J (2019)[23]	*		*	*	*	*	*	*	7
Bhandari SK (2020)[24]	*	*	*	*	**	*	*	*	9
Vala CH (2020)[25]	*	*	*		**	*	*	*	8
Clinical trial	**Selection**				**Comparability**	**Exposure**			**Overall**
	Is the case definition adequate?	**Representativeness of the cases**	**Selection of controls**	**Definition of controls**		**Ascertainment of exposure**	**Same method of ascertainment for cases and controls**	**Non-response rate**	
Pekkarinen T (2013)[17]	*	*	*	*	**	*	*		8

Table 2: Studies reporting risk factors of hip fracture

ID	Author (years of publication)	Geographical area of the study	Type of study	Age	Sample size (male and female)	Sample size (male)	Sample size (female)	Case	Control	Risk factor
1	Woo SH (2020)[9]	Korea	Retrospectively	>60	507	173	334			Sex
										Age ≥75
										Osteoporosis medication
										Hypertension
										Diabetes mellitus
										Myocardial infarction
										Cerebrovascular accidents
										Liver disease
										Chronic kidney disease
2	Ottenbacher KJ (2002)[10]	Mexican American	Prospective cohort	>65	2884	1213	1671			Insulin diabetes
										Age
										Sex (female)
										Ever smoker
										BMI
										Stroke
										Diabetes mellitus
										Age
										Sex (female)
										Ever smoker
										BMI
										Stroke
3	Walter LC (2003[11]	USA	Prospective cohort study	55–104	5187					Age ≥75
					2548					Ethnicity (white)
					366					Transferring (independent or partially dependent)
					5187					Age ≥75
					718					Asian
					624					Latino
					2548					White
					3678					Sex (female)
					1555					Living situation (Home alone)
					987					Living situation (group alone)
					449					Toileting (dependent)
					366					Transferring (independent or partially dependent)
					526					Walking (dependent)
4	Wainwright SA (2005)[12]	USA	Cohort	≥65			6667			Age (without osteoporosis)
							6667			Walking for exercise
							6667			Other activity: Alone or in addition to walking
							6667			Contrast sensitivity, low frequency
							6667			Any falls in last year
							6667			Prevalent vertebral fracture
							6667			Total hip bone mineral density (per SD decrease)
							1398			Previous hyperthyroidism (with osteoporosis)
							1398			Distance depth perception: Lowest quartile

Contd...

Table 2: Contd...

ID	Author (years of publication)	Geographical area of the study	Type of study	Age	Sample size (male and female)	Sample size (male)	Sample size (female)	Case	Control	Risk factor
							1398			Contrast sensitivity, low frequency
							1398			Grip strength (per 5 kg)
							1398			Prevalent vertebral fracture
							1398			Total hip bone mineral density (per SD decrease)
5	Alfaro-Acha A (2006)[13]	USA	Prospective cohort	≥65	2653	1117	1531			BMI
										Age
										Sex (female)
										Unmarried
										Current smoker
										Vision scale
										Short physical performance battery
										Medical conditions (heart attack, stroke, diabetes, and arthritis)
6	Nakamura K (2009)[14]	Japan	Cohort study	<80–≥90	7654	1565	4085			Dementia
					7654					Total score of the Barthel index
					3579					Special nursing homes
					4085					Sex (female)
					2664					Age group (80–89)
					1322					≥90
					490					Vision (partially or blind)
					859					Hearing (having partial or total hearing loss)
					1338					Levels of dementia (light)
					1643					Levels of dementia (moderate)
					684					Levels of dementia (severe)
					2400					Calcium supplementation
					481					Past history of upper or lower limb fractures
					183					Past history of other fractures
7	Barzilay JI (2013)[15]	USA	Cohort	≥65		1276				Albuminuria
							1834			Albuminuria
8	Furuya T (2013)[16]	Japan	Cohort	42–69	9720		7980			Sex (female)
										Age
										BMI
										DAS28
										J-HAQ score (total)
										J-HAQ score (arising)
										J-HAQ score (hygiene)
										J-HAQ score (eating)
										J-HAQ score (activity)
										J-HAQ score (walking)
										J-HAQ score (dressing)
										J-HAQ score (reaching)
										J-HAQ score (gripping)
										Patient pain VAS
										Physician global VAS
										CRP 0.3–1.0 vs ≤0.3 mg. 100 Ml
										CRP >1.0 vs ≤0.3 mg. 100 ml
										History of any prior fracture

Contd...

Table 2: Contd...

ID	Author (years of publication)	Geographical area of the study	Type of study	Age	Sample size (male and female)	Sample size (male)	Sample size (female)	Case	Control	Risk factor
										History of TKR
										Daily prednisolone dose, mg 1 day
										Bisphosphonate use
										Active vitamin D3 use
										Proton pump inhibitor use
										Biologic use
										Weekly MTX dos
										Folic acid use
										Duration of RA 2–10 years vs <2 years
										Duration of RA >10 years vs <2 years
										RF positive (>20 IU/mL)
9	Pekkarinen T (2013)[17]	Finland	Controlled trial	60–70			2178			Smoking
										Age
										Fall history
										Stroke history
					15431					Schizophrenia diagnosis
10	Sørensen HJ (2013)[18]	Denmark	Cohort	NA	3353771					Sex (male)
										Age
										Early retirement pension
										Somatic score ≥1
										Antipsychotic
										Corticosteroids
										Lifetime alcohol abuse
										Antidepressants
										Anticholinergics
										Benzodiazepines
11	Lobo E (2018)[19]	Spanish	Longitudinal	>55	4660	1976				Mini-mental Status Examination (MMSE) in men
										MMSE Staging (questionable)
										Mild
										Moderate
										Severe
										Petersen's mild cognitive impairment (MCI-P)
								2684		MMSE in women
										MMSE staging (questionable) mild
										Moderate
										Severe
										Petersen's mild cognitive impairment (MCI-P)
										DSM-5 mild neurocognitive disorder
12	Wang HK (2014)[20]	Taiwan	Retrospective, cohort	≥60	1408					Dementia
					183					Alzheimer
					1225					Unspecific dementia
					1059					Dementia non-osteoporosis group
					349					Dementia osteoporosis group

Contd...

Table 2: Contd...

ID	Author (years of publication)	Geographical area of the study	Type of study	Age	Sample size (male and female)	Sample size (male)	Sample size (female)	Case	Control	Risk factor
13	Stenholm S (2015)[21]	Swedish	Prospective cohort	16–65		11232				Being on sick leave for >3 months
						2375				Being on sick leave (1–15 days)
						26109				Being on sick leave (16–75 days)
						14276				Being on sick leave (166–365 days)
							13078			Being on sick leave for >3 months
							29984			Being on sick leave (1–15 days)
							33347			Being on sick leave (16–75 days)
							14514			Being on sick leave (166–365 days)
14	Tal S (2015)[22]	Israel	Retrospective study	>65	1161	303	858			Sex (female)
										Frailty
										Fall
										Diabetes mellitus
										Parkinson's disease
										Normal calcium
										Normal albumin
										Normal hemoglobin
15	Kim J (2019)[23]	South Korea	Retrospective cohort	≥65	90012					Sex (women)
										Age 70–74
										75–79
										80–84
										>85
										Type of health security
										Household income (low)
										Household income (middle)
										Severity of disability (severe)
										Severity of disability (mild)
										Charlson comorbidity index (1–2)
										Charlson comorbidity index+3
										Stroke
										Parkinson
										Osteoporosis
16	Bhandari SK (2020)[24]	USA	Retrospective cohort	≥55						Hyponatraemia
										Sub-acute hyponatraemia
										Chronic hyponatraemia
17	Vala CH (2020)[25]	Swedish	Retrospective cohort	60–100			128344			Month 0–6 in men After death of a spouse compared with still-married men
										Month 6–12
										Year 2
										Year 3
										Year 4
						299067				Over 5 years
										Month 0–6 in women after the death of a spouse compared with still-married men
										Month 6–12
										Year 2
										Year 3
										Year 4
										Over 5 years

Contd...

Table 2: Contd...

ID	OR	HR (adjusted)	HR (unadjusted)	RR (relative risks; adjusted)	RR (unadjusted)	Incidence rate ratio (IRR)
1	1.92 (0.91–4.02)					
	1.16 (0.61–2.21)					
	0.55 (0.20–1.46)					
	1.75 (0.92–3.31)					
	1.44 (0.69–3.01)					
	1.57 (0.50–4.88)					
	1.48 (0.54–4.08)					
	1.20 (0.26–5.50)					
	1.38 (0.44–4.37)					
2		2.84 (1.49–5.43)				
		1.06 (1.03–1.09)				
		1.7 (1.07–2.72)				
		1.12 (0.73–1.73)				
		0.95 (0.91–0.99)				
		1.49 (0.65–3.42)				
		1.57 (1.03–2.39)				
		1.06 (1.03–1.09)				
		1.86 (1.21–2.88)				
		1.03 (0.69–1.54)				
		0.96 (0.92–1.00)				
		1.21 (0.56–2.61)				
3		2.00 (1.40–2.80)				
		2.10 (1.60–2.80)				
		3.00 (1.20–7.20)				
			2.30 (1.60–3.20)			
			1.30 (0.80–2.20)			
			1.50 (0.90–2.70)			
			2.50 (1.70–3.80)			
			1.50 (1.10–2.00)			
			1.50 (1.10–2.20)			
			2.70 (1.90–3.90)			
			1.70 (1.00–3.20)			
			3.10 (1.30–7.60)			
			2.30 (1.20–4.30)			
4		1.08 (1.05–1.12)				
		0.73 (0.48–1.09)				
		0.50 (0.32–0.78)				
		1.54 (1.06–2.25)				
		1.64 (1.15–2.34)				
		1.86 (1.28–2.71)				
		1.95 (1.53–2.46)				
		1.86 (1.11–3.10)				
		1.67 (1.11–2.53)				
		1.56 (1.03–2.37)				
		0.74 (0.59–0.94)				
		1.52 (1.00–2.29)				
		1.52 (1.09–2.10)				
5		0.98 (0.94–1.03)				
		1.03 (0.99–1.07)				
		1.45 (0.85–2.49)				
		0.90 (0.55–1.47)				
		0.81 (0.49–1.34)				

Contd...

Table 2: Contd...

ID	OR	HR (adjusted)	HR (unadjusted)	RR (relative risks; adjusted)	RR (unadjusted)	Incidence rate ratio (IRR)
		1.08 (0.74–1.59)				
		0.94 (0.87–1.02)				
		1.30 (1.00–1.68)				
6				1.87 (1.12–3.12)		
				2.66 (1.57–4.53)		
					1.76 (1.10–2.82)	
					2.00 (1.13–3.53)	
					2.00 (1.16–3.46)	
					1.80 (0.95–3.38)	
					0.91 (0.42–1.98)	
					1.16 (0.67–2.02)	
					2.50 (1.41–4.42)	
					1.96 (1.10–3.50)	
					1.92 (0.93–3.65)	
					1.37 (0.91–2.60)	
					1.66 (0.90–3.04)	
					0.70 (0.17–2.83)	
7		1.02 (0.89–1.17)	1.13 (1.02–1.27)			
		1.12 (1.00–1.25)	1.15 (1.05–1.25)			
8		0.74 (0.40–1.35)	1.01 (0.58–1.76)			
		1.56 (1.26–1.91)	1.87 (1.53–2.28)			
		0.91 (0.85–0.97)	0.92 (0.86–0.99)			
		0.84 (0.64–1.10)	1.33 (1.14–1.56)			
			2.99 (2.37–3.77)			
		1.74 (1.28–2.36)	2.40 (1.99–2.88)			
		1.58 (1.11–2.24)	2.63 (2.11–3.29)			
		1.18 (0.83–1.67)	2.05 (1.70–2.47)			
		1.14 (0.80–1.63)	2.22 (1.84–2.67)			
		1.03 (0.74–1.42)	2.36 (1.94–2.88)			
		0.96 (0.68–1.36)	2.23 (1.82–2.72)			
		0.84 (0.59–1.20)	1.95 (1.62–2.34)			
		0.87 (0.62–1.23)	1.89 (1.62–2.34)			
		1.01 (0.99–1.01)	1.02 (1.01–1.02)			
		1.00 (0.99–1.02)	1.01 (1.00–1.03)			
		1.46 (0.86–2.47)	1.93 (1.17–3.19)			
		1.03 (0.57–1.88)	1.84 (1.11–3.04)			
		1.34 (0.86–2.10)	1.61 (1.04–2.50)			
		3.28 (1.37–7.83)	7.34 (3.17–16.96)			
		1.01 (0.96–1.07)	1.04 (1.01–1.06)			
		1.07 (0.65–1.77)	2.01 (1.25–3.23)			
		1.38 (0.85–2.24)	2.31 (1.44–3.69)			
			1.40 (0.72–2.69)			
			0.68 (0.17–2.77)			
			1.02 (0.98–1.07)			
			1.11 (0.70–1.76)			
			1.11 (0.36–3.43)			
			2.16 (0.72–6.53)			
			1.32 (0.81–2.14)			
9	4.32 (2.14–8.71)					
	1.15 (1.03–1.28)					
	2.27 (1.24–5.90)					

Contd...

Table 2: Contd...

ID	OR	HR (adjusted)	HR (unadjusted)	RR (relative risks; adjusted)	RR (unadjusted)	Incidence rate ratio (IRR)
	2.99 (1.19–7.54)					
						1.00 (0.90–1.11)
10						0.73 (0.71–0.74)
						1.08 (1.08–1.08)
						2.33 (2.26–2.39)
						1.09 (1.07–1.11)
						1.19 (1.15–1.24)
						1.44 (1.36–1.53)
						2.80 (2.72–2.87)
						1.18 (1.16–1.12)
						1.29 (1.22–1.36)
						1.06 (1.04–1.08)
11		0.93 (0.89–0.97)				
		1.88 (0.56–6.28)				
		4.99 (1.39–17.91)				
		2.51 (0.39–16.43)				
		9.31 (1.35–64.06)				
		0.61 (0.15–2.56)				
		0.98 (0.95–1.01)				
		0.88 (0.52–1.48)				
		1.37 (0.79–2.40)				
		1.03 (0.50–2.12)				
		2.81 (0.91–8.62)				
		1.19 (0.72–1.98)				
		1.10 (0.60–2.02)				
12		1.92 (1.48–2.49)	2.03 (1.63–2.52)			
		2.19 (1.43–1.87)	2.31 (1.57–2.76)			
		1.87 (1.33–2.83)	2.01 (1.49–2.93)			
		1.84 (1.37–2.46)	2.04 (1.59–2.62)			
		2.27 (1.28–4.01)	1.98 (1.24–4.01)			
13		1.96 (1.74–2.20)				
		1.40 (1.27–1.56)				
		1.21 (1.13–1.31)				
		1.31 (1.22–1.14)				
		1.55 (1.41–1.70)				
14	1.39 (1.05–1.82)					
	1.36 (1.06–1.75)					
	1.49 (1.16–1.90)					
	1.33 (1.02–1.72)					
	0.60 (0.41–0.87)					
	0.68 (0.52–0.89)					
	1.27 (0.92–1.74)					
	0.70 (0.55–0.89)					
15	1.49 (1.39–1.61)					
	1.67 (1.52–1.83)					
	3.04 (2.77–3.32)					
	4.17 (3.77–4.60)					
	4.09 (3.62–4.62)					
	0.52 (0.45–0.59)					

Contd...

Table 2: Contd...

ID	OR	HR (adjusted)	HR (unadjusted)	RR (relative risks; adjusted)	RR (unadjusted)	Incidence rate ratio (IRR)
	1.00 (0.92–1.09)					
	0.98 (0.91–1.06)					
	1.59 (1.33–1.89)					
	1.68 (1.49–1.88)					
	1.10 (1.02–1.18)					
	1.24 (1.03–1.49)					
	1.27 (1.13–1.43)					
	1.51 (1.04–2.19)					
	1.35 (1.24–1.46)					
16		1.30 (1.22–1.39)				
		1.52 (1.42–1.62)				
		1.00 (0.92–1.08)				
17		1.84 (1.68–2.03)				
		1.60 (1.47–1.74)				
		1.54 (1.44–1.64)				
		1.50 (1.40–1.61)				
		1.38 (1.27–1.50)				
		1.33 (1.28–1.38)				
		1.62 (1.53–1.71)				
		1.51 (1.43–1.60)				
		1.47 (1.41–1.54)				
		1.38 (1.32–1.45)				
		1.36 (1.30–1.42)				
		1.38 (1.34–1.42)				

OR (95%CI)=odds ratios (OR) and 95% confidence intervals (95% CI), HR (95%CI)=hazard ratio (HR) and 95% confidence intervals (95% CI), RR (95%CI)=relative risk (RR) and 95% confidence intervals (95% CI), IRR (95%CI)=incidence rate ratio (IRR) and 95% confidence intervals (95% CI)

factors, including bone density and falls, both of which are potentially influenced by high blood pressure. In addition, blood pressure predicts hip fractures in women more than men.[32] However, blood pressure patients who are treated with thiazides have fewer fractures due to higher bone density.[33]

Diabetes mellitus and insulin diabetes

Diabetes mellitus increases the risk of hip fracture by 57% [Table 2]. The adverse effects of diabetes on the skeletal structure and increasing the risk of osteoporosis, the reduction of cartilage tissue and mineral salts, and finally, the incidence of fracture have been reported in many studies.[34-36] A meta-analysis study found that in patients with hip fractures, the risk of developing pressure sore showed a significant increase.[37] On the other hand, diabetes due to complications, such as neuropathy, retinopathy, cognitive impairment, muscle weakness, and hypoglycemic events caused by the use of antidiabetic drugs, puts a person at risk of falling.[38] In this study, insulin use significantly increased the risk of hip fracture HR = 2.84 (95% CI: 1.49–5.43) [Table 2]. Long-term use of insulin with anabolic effects on bone tissue plays an important role in increasing the risk of fracture.[35,39]

Myocardial infarction

The chance of hip fracture in patients with myocardial infarction was reported to be 57 times more than others [Table 2]. One of the most important causes of death in hip fracture patients or those who undergo hip fracture surgery is cardiovascular diseases, especially myocardial infarction.[40,41] Some genetic factors, such as oxidative stress, which significantly increases in the elderly with hip fractures, may be the determining factor in the relationship between bone mass reduction, fracture, and cardiovascular diseases.[42,43]

Cerebrovascular accidents and stroke

The mechanism of stroke in hip fracture patients is somewhat unknown although factors, such as physical immobility, mental stress, and post-fracture pain, play a significant role in its occurrence.[44] Embolism in the brain through internal or external shunts of the heart, as well as the systemic hypercoagulative state after surgery for femur fracture, is effective in causing stroke.[45,46] On the other hand, hospitalization and surgery of hip fracture patients with physiological changes during anesthesia make the person susceptible to cerebrovascular accidents.[44] In a study, the mortality rate in hip fracture patients with a history of stroke was higher than other patients who did not have a history of stroke,[47] which can be the reason for the importance and clinical attention to prevent falls in these patients.[48] In the present study, the findings show a 2.99 times greater chance of hip fracture in patients with a stroke [Table 2].

Liver disease

According to the findings, the chance of hip fracture in liver patients is 1.2 times higher than in others [Table 2]. Studies have indicated that the risk of osteoporosis and hip fracture increases in patients with liver diseases.[49,50] In addition, the low level of insulin-like growth factor 1 (IGF-1) in patients with advanced liver cirrhosis may destroy the regeneration and preservation of bone mass in elderly patients and cause fractures.[49] Liver disorders are often associated with the risk of venous thromboembolism, hypo and hypercoagulopathy, infection, hemodynamic instability, and malnutrition. On the other hand, a disorder in bone tissue metabolism is associated with a decrease in recovery and a delay in the patient's mobility, and all of these factors may cause the patient's death.[51]

Chronic kidney disease and albuminuria

In the current study, kidney diseases increased the chance of hip fracture by 38% [Table 2]. The increased risk of hip fracture in patients with kidney diseases may be related to mineral, bone, and weakness disorders.[52] In addition, the decrease in kidney function is associated with the disorder of the parathyroid–calcium–phosphate axis.[53] It is worth mentioning that calcium and phosphate are the main mineral components of bone. In addition, hyperphosphatemia has a positive relationship with the occurrence of fractures in patients with chronic kidney diseases.[54] A decrease in bone density due to hyperphosphatemia can be due to the increase of osteoblasts through IGF-1 and the osteopontin gene.[55] Parathyroid hormone changes bone cell proliferation, especially osteoblasts and osteoclasts, which may affect calcium absorption and bone metabolism.[56] In addition, the increase in albumin levels in kidney disorders is directly related to the occurrence of osteoporosis and fractures. Aging of the musculoskeletal system causes the loss of muscle mass and physical strength, which plays a crucial role in creating the risk of fractures.[15]

Smoking

Smoking showed a significant relationship with the risk of hip fracture, OR = 4.32 (95% CI: 2.14–8.71) [Table 2]. Smoking disrupts calcium absorption and vitamin D metabolism and reduces bone density by reducing the level of 25-hydroxy vitamin D.[56] Smoking usually causes people to lose weight by reducing their appetite and increasing the free radicals level, causing bone decay and eventually fracture.[57] In addition, the reduction in the consumption of vitamins E and C in smokers and the toxic effect of nicotine in cigarettes reduce blood supply to bones and increases the risk of hip fracture.[58,59]

Alcohol

In this study, lifelong alcohol consumption was associated with a significant increase in the incidence of hip fracture [Table 2]. Studies have indicated that excessive or moderate alcohol consumption in the elderly can be associated with the risk of fractures. It is worth mentioning that the effect of alcohol on the occurrence of fractures varies depending on the amount of bone damage. Excessive consumption of alcohol by reducing bone density or by changing endocrine signals and having a negative effect on bone regeneration plays an important role in the occurrence of fractures.[60,61]

BMI

Low weight along with weakness, chronic inflammation, and reduced physical health increases the risk of falling and fractures. Underweight increases the risk of hip fracture by reducing bone mineral density (BMD). On the other hand, obesity has a protective effect on fractures by increasing the BMD and reducing the impact of falls due to the soft tissue layer.[62,63] According to the findings, BMI has a protective effect on hip fracture [Table 2].

Ethnicity

Ethnicity through genetic factors and factors, such as smoking, nutrition, physical activity, and mineral concentration, play an important role in osteoporosis and fractures.[64] Studies have shown a high rate of hip fracture in European and American countries, but Latin American, African, and Asian countries have the lowest rate.[65,66] In this study, the risk of hip fracture was significantly observed in white people more than in others [Table 2].

Transferring

The risk of hip fracture in those who were able to move without the help of others was significantly higher than in those who were dependent on others for moving HR = 3.0 (95% CI: 1.2–7.2) [Table 2]. Studies have shown that the elderly who are dependent on others for moving are less prone to fractures. On the other hand, a person's dependence on others is associated with a decrease in quality of life, a decrease in mobility, and an increase in bedsores.[11] The risk of fracture in people who are able to move causes a conflict between important goals such as maintaining the individual's independence and preventing fracture.[67]

Living situation

Living alone in the elderly significantly increased the risk of hip fracture HR = 1.5 (95% CI: 1.1–2.2) [Table 2]. Studies have shown that the survival rate in patients with hip fractures is higher in people who live alone.[68,69] The link between social relationships with better functioning of the immune system and the reduction of inflammatory processes over time can have a positive effect in all parts of life. Social support can have an important effect named 'buffering effect' on stress during hip fracture.[69,70]

Walking

In this study, walking played a protective role against hip fracture [Table 2]. Epidemiological studies have shown that the risk of hip fracture decreases by increasing physical activity. Activities, such as cleaning, gardening, walking, and cycling, have an inverse relationship with hip fractures in the elderly.[71,72] In a prospective study, elderly women who did housework for more than 9 hours had 22% fewer hip fractures compared to those who did 5 hours a day.[73]

Fall and vertebral fracture

Falling significantly increased the chance of hip fracture OR = 2.27 (95% CI: 1.24–5.90) [Table 2]. According to studies, more than 90% of hip fractures in the elderly occur due to falls.[74,75] Falling on the side causes a severe blow to the trochanter, which causes excessive pressure on the superolateral cortex of the femur, where the bone structure has a thin cortex due to old age and is inherently fragile.[76,77]

In the present study, the risk of hip fracture was 86% higher in those with vertebral fractures than others [Table 2]. In a study, the results showed that a quarter of the people who were referred with hip fractures had asymptomatic vertebral fractures at the same time.[78] The results of studies have shown that the risk of hip fracture in women whose vertebrae are deformed is 3.4 times higher than in other women. Therefore, the radiologist's clinical evaluation of vertebral fractures can be effective in identifying women who are at risk of hip and spine fractures.[79] Vertebral fractures along with hip fractures are often due to osteoporosis and low bone quality.[78]

BMD

BMD is the main determinant of the risk of fractures caused by osteoporosis.[80] BMD decreases in people aged over 50 years so the amount of BMD reduction in the femoral neck is 0.64% before the age of 65 and 0.36% after the age of 65.[81] By decreasing one standard deviation in BMD, the risk of hip fracture increases 2.6 times.[82] In the current study, the risk of hip fracture was significantly related to BMD (HR = 1.95 (95% CI: 1.53–2.46) [Table 2].

Hyperthyroidism

Hyperthyroidism was associated with an 86% increase in the risk of hip fracture [Table 2]. Hyperthyroidism in adults is one of the causes of secondary osteoporosis and ultimately fractures. On the other hand, excessive treatment with levothyroxine and thyroid stimulating hormone (TSH) suppressive therapy plays an important role in reducing BMD and finally fractures.[83] In subclinical hyperthyroidism, the TSH serum level in the presence of free triiodothyronine (T3) and free thyroxine (T4) is at the lowest normal level, which can be associated with a decrease in bone health and affect the occurrence of fractures.[84,85]

Grip strength

Evaluating handgrip strength (HGS) is a general measure of body strength and physical performance. HGS has been reported as one of the important functional outcomes in hip fracture patients.[86,87] The decrease in muscle strength reduces the mechanical load of the body's skeleton and is associated with a decrease in bone regeneration. Moreover, the loss of muscle mass leads to impaired neuromuscular function and a decrease in mechanical load and ultimately increases the risk of falls and fractures.[88] According to the findings of the present study, the risk of hip fracture showed a significant relationship with HGS [Table 2].

After the death of a spouse and single

Being single had a protective effect against hip fracture, while the death of a spouse increased the risk of fracture by 62% [Table 2]. Reports have indicated that women who have lost their spouses are mostly suffering from one or more chronic diseases, such as high blood pressure, diabetes, heart disease, stroke, and reduced physical activity and stress, caused by the death of their spouses and their conditions have worsened compared to before.[25] It can also lead to an unhealthy diet and more use of cigarettes and alcohol, which is effective in increasing the risk of hip fracture and can be seen years after the death of the spouse. On the other hand, the findings of studies have shown the relationship between being single and death after hip fracture due to the lack of social support.[70,89] Increased death and decreased survival after hip fractures have also been seen in young men who live alone.[70]

Vision

Poor vision is very common in the elderly. Diseases, such as cataracts, glaucoma, and macular degeneration, are all strongly age-related. Poor vision or differences in visual acuity between eyes, as well as reduced contrast sensitivity, were associated with an increased risk of fracture,[90] which is consistent with the findings of the present study regarding the relationship between visual impairment and the risk of hip fracture [Table 2].

Hearing

According to the present study, hearing increases the risk of hip fracture by 16% [Table 2]. The pathophysiological relationship between hip fracture and chronic otitis media can be due to inflammation and genetic factors. Inflammation plays a role in the pathogenesis of hearing and osteoporosis. Osteoporosis is associated with a decrease in bone mass as well as in bone density of the cochlea and a disturbance in sound transmission to the cochlea, which ultimately leads to hearing loss.[91] Therefore, it seems necessary to examine the middle ear in patients with osteoporosis. In addition, the relationship between hearing loss and falls and eventually fractures has been proven in studies.[92]

Dementia

The prevalence of dementia increases with age. In Alzheimer's disease with mild, moderate, and severe spectrum, hip fracture has been reported to be relatively constant.[93] In patients with dementia and hip fracture, some risk factors are the same such as weight loss, low vitamin D levels, decreased digestive absorption of calcium, and increased parathyroid hormone levels. Decreasing the level of vitamin D and calcium is effective in reducing bone density and plays an important role in hip fracture.[94] In the present study, dementia significantly increased the risk of hip fracture [Table 2].

Psychopathology and Pharmacological Treatment

No significant relationship was found between the incidence of hip fracture and schizophrenia. However, there was a significant relationship between antipsychotics, antidepressants, anticholinergics, corticosteroids, and benzodiazepines with the incidence of hip fracture [Table 2]. The occurrence of fractures in schizophrenia patients can be due to the effects of psychoactive drugs and low quality of life. On the other hand, the side effects of some antipsychotics, antidepressants, and benzodiazepines such as sedation, drowsiness, and orthostatic hypotension affect people's balance and walking, leading to falls and ultimately fractures.[95] In addition, the femoral head is vulnerable to corticosteroids due to the stress of weight bearing and reverse blood flow. Also, corticosteroids with hypertrophy of fat cells can cause venous occlusion, vessel occlusion, compression of small veins, and increase the pressure inside the bone, resulting in blood stasis, ischemia, and bone death.[96]

Parkinson's disease

Parkinson's disease is associated with low levels of bone density, vitamin D deficiency, osteoporosis, and fractures.[97] On the other hand, falls in patients with Parkinson's disease are associated with reduced functional ability and finally death. Studies have shown that prevention with vitamin D and bisphosphonates can be effective in reducing the risk of non-vertebral fractures in patients with Parkinson's disease.[98,99] In this study, Parkinson's disease significantly increased the chance of hip fracture by 51% [Table 2].

Arthritis

In the present study, a history of arthritis significantly increased the risk of hip fracture [Table 2]. Chronic inflammation, use of glucocorticoids, and lack of physical activity cause bone tissue loss in patients with rheumatoid arthritis (RA) and the risk of osteoporosis increases. The release of pro-inflammatory cytokines, such as interleukin 1 (IL-1), IL-6, and tumor necrosis factor-α, causes the abnormal production of osteoclasts and the balance between absorption and bone formation is disturbed. Moreover, immobility caused by inflammation, muscle pain, weakness, and swelling caused by RA may increase the risk of falling to some extent and thus increase the rate of bone fracture.[100]

Hyponatraemia

Studies have indicated that hyponatraemia significantly increases the risk of hip fracture. HR = 1.30 (95% CI: 1.22–1.39) [Table 2]. Hyponatraemia is usually asymptomatic or manifests with symptoms such as walking disorder, falling, or impaired bone fracture healing.[101] It can also play an effective role in reducing cellular immunity by disrupting the function of IL-17 and the production of T helper cells. On the other hand, it can accelerate the aging process by causing osteopenia, hypogonadism, sarcopenia, cardiomyopathy and reducing body fat. These factors also increase the risk of death by increasing weakness in the elderly.[102]

Calcium and vitamin D3

According to the findings of the present study, the consumption of calcium and vitamin D3 had no significant relationship with the occurrence of hip fracture [Table 2]. Vitamin D is necessary for optimal skeletal-muscular health with calcium absorption, mineralization, formation of osteoid tissue in bones, and maintenance of muscle function. The low status of vitamin D causes secondary hyperparathyroidism, bone loss, and muscle weakness. On the other hand, consuming high doses of vitamin D by producing toxic effects in the body can be associated with an increase in the risk of falls and fractures.[103] In addition, the results of meta-analysis studies have indicated the fact that the consumption of vitamin D alone is not effective in reducing the risk of hip fracture in the elderly.[104]

Past history of upper or lower limb fractures and other fractures

According to studies, having a history of fracture can predict the risk of fracture due to osteoporosis and hip fracture in shorter periods.[105,106] About 25% of patients with a history of fracture experience subsequent fractures, since the risk level of the next fracture is cumulative and the risk level does not return to the level before the fracture.[107] In this study, there was no significant relationship between the history of fracture and the risk of hip fracture [Table 2].

Cognitive impairment and frailty: Being on sick leave for more than 3 months

Maintaining cognitive function with factors, such as aging, trauma, and multiple diseases, can be a sign of brain resilience. Being physically fit, mastering several languages, and having a higher education level can lead to brain resilience. On the other hand, these factors play an important role in predicting cognitive improvement after hip fracture.[108] In this study, no significant relationship was found between cognitive disorders and the risk of hip fracture, while long-term absence from work and weakness increased the risk of hip fracture by 96% and 36%, respectively [Table 2]. Long-term absence indicates a person's lack of health, and suffering from some chronic diseases, reduced immunity, and low quality of life increase the risk of falling and eventually fractures.[21] Therefore, information related to the long-term absence of people can be very effective in identifying high-risk groups of hip fractures.

Weakness is a state of vulnerability caused by a decrease in the ability to maintain or restore homeostasis in the face of stressful factors.[109] In most studies, weakness is a predictor of outcomes such as mortality,[110] incidence of complications,[111] length of hospitalization,[112] quality of life, and discharge.[113] Studies have mentioned the relationship between weakness and the risk of hip fracture.

Household income

The results indicated that the income level of the family had no significant relationship with the incidence of hip fracture [Table 2], while some studies have mentioned the relationship between the low level of income and the incidence of hip fracture. The low levels of income, education, and physical activity in leisure time can be effective in the occurrence of fractures.[114,115] However, the increase in income level is also associated with eating habits that may lead to the occurrence of osteoporosis and ultimately fractures.[116]

Death of a spouse

The study results showed a significant increase in the risk of hip fracture in overweight men who lost their spouses [Table 2]. Stressful events in life are associated with a decrease in hip bone density and an increase in falls and fractures.[25] Loneliness can increase the risk of hip fracture by 85%. Mourning also increases the risk of death in people, although the risk of death decreases with time.[117]

Conclusion

The results of this study reveal the determining role of some risk factors including sociodemographic factors, lifestyle factors, diseases, physical factors, and social factors on hip fractures among the elderly. Therefore, it is recommended that health policymakers provide the possibility of early intervention for some changeable factors.

Financial support and sponsorship

This work was conducted as part of the NIMAD project (Design, Implementation and Evaluation of a Comprehensive Model of Post-Hospital Care Management for Patients with Hip Fracture, Focusing on Frailty and Disability (Grant no. 984322).

Conflicts of interest

There are no conflicts of interest.

Received: 09 Jul 23 **Accepted:** 20 Feb 24
Published: 30 Aug 24

References

1. Schwarz GM, Hajdu S, Windhager R, Willegger M. The top fifty most influential articles on hip fractures. Int Orthop 2022;46:2437-53.
2. Ahmadi-Abhari S, Moayyeri A, Abolhassani F. Burden of hip fracture in Iran. Calcif Tissue Int 2007;80:147-53.
3. Naranjo A, Molina A, Quevedo A, Rubiño FJ, Sánchez-Alonso F, Rodríguez-Lozano C, *et al*. Long-term persistence of treatment after hip fracture in a fracture liaison service. Sci Rep 2022;12:9373.
4. Zhang Y, Fu M, Guo J, Zhao Y, Wang Z, Hou Z. Characteristics and perioperative complications of hip fracture in the elderly with acute ischemic stroke: A cross-sectional study. BMC Musculoskelet Disord 2022;23:1-8.
5. Moayyeri A, SOLTANI A, Abolhassani F. Incidence of hip fractures among Iranian elderly population. Iran J Public Health 2004;33:29-33.
6. Veronese N, Maggi S. Epidemiology and social costs of hip fracture. Injury 2018;49:1458-60.
7. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, *et al*. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. PLoS Med 2021;18:e1003583.
8. Fahmy O, Fahmy UA, Alhakamy NA, Khairul-Asri MG. Single-port versus multiple-port robot-assisted radical prostatectomy: A systematic review and meta-analysis. J Clin Med 2021;10:5723.
9. Woo S-H, Park K-S, Choi I-S, Ahn Y-S, Jeong D-M, Yoon T-R. Sequential bilateral hip fractures in elderly patients. Hip pelvis 2020;32:99.
10. Ottenbacher KJ, Ostir GV, Peek MK, Goodwin JS, Markides KS. Diabetes mellitus as a risk factor for hip fracture in Mexican American older adults. J Gerontol A Biol Sci Med Sci 2002;57:M648-53.
11. Walter LC, Lui LY, Eng C, Covinsky KE. Risk of hip fracture in disabled community-living older adults. J Am Geriatr Soc 2003;51:50-5.
12. Wainwright SA, Marshall LM, Ensrud KE, Cauley JA, Black DM, Hillier TA, *et al*. Hip fracture in women without osteoporosis. J Clin Endocrinol Metab 2005;90:2787-93.
13. Acha A, Ostir G, Markides K, Ottenbacher K. Cognitive status, body mass index and hip fracture in hispanic older adults. J Am Geriatr Soc 2006;54:1251-5.
14. Nakamura K, Takahashi S, Oyama M, Nashimoto M, Saito T, Tsuchiya Y, *et al*. Incidence and risk factors associated with hip fracture in institutionalised elderly people in Japan. Age Ageing 2009;38:478-82.
15. Barzilay J, Bůžková P, Chen Z, De Boer I, Carbone L, Rassouli N, *et al*. Albuminuria is associated with hip fracture risk in older adults: The cardiovascular health study. Osteoporos Int 2013;24:2993-3000.
16. Furuya T, Inoue E, Hosoi T, Taniguchi A, Momohara S, Yamanaka H. Risk factors associated with the occurrence of hip fracture in Japanese patients with rheumatoid arthritis: A prospective observational cohort study. Osteoporos Int 2013;24:1257-65.
17. Pekkarinen T, Löyttyniemi E, Välimäki M. Hip fracture

prevention with a multifactorial educational program in elderly community-dwelling Finnish women. Osteoporos Int 2013;24:2983-92.

18. Sørensen HJ, Jensen SO, Nielsen J. Schizophrenia, antipsychotics and risk of hip fracture: A population-based analysis. Eur Neuropsychopharmacol 2013;23:872-8.
19. Lobo E, Marcos G, Santabárbara J, Lobo-Escolar L, Salvador-Rosés H, De la Cámara C, *et al*. Gender differences in the association of cognitive impairment with the risk of hip fracture in the older population. Maturitas 2018;109:39-44.
20. Wang H-K, Hung C-M, Lin S-H, Tai Y-C, Lu K, Liliang P-C, *et al*. Increased risk of hip fractures in patients with dementia: A nationwide population-based study. BMC Neurol 2014;14:1-8.
21. Stenholm S, Vahtera J, Kjeldgård L, Kivimäki M, Alexanderson K. Length of sick leave as a risk marker of hip fracture: A nationwide cohort study from Sweden. Osteoporos Int 2015;26:943-9.
22. Tal S, Gurevich A, Sagiv S, Guller V. Differential impact of some risk factors on trochanteric and cervical hip fractures. Geriatr Gerontol Int 2015;15:443-8.
23. Kim J, Jang S-N, Lim J-Y. Pre-existing disability and its risk of fragility hip fracture in older adults. Int J Environ Res Public Health 2019;16:1237.
24. Bhandari SK, Adams AL, Li BH, Rhee CM, Sundar S, Krasa H, *et al*. Sub-acute hyponatraemia more than chronic hyponatraemia is associated with serious falls and hip fractures. Intern Med J 2020;50:1100-8.
25. Vala C, Lorentzon M, Sundh V, Johansson H, Lewerin C, Sten S, *et al*. Increased risk for hip fracture after death of a spouse—further support for bereavement frailty? Osteoporos Int 2020;31:485-92.
26. Liu F, Chang W-j, Wang X, Gong R, Yuan D-t, Zhang Y-K, *et al*. Risk factors for prolonged preoperative waiting time of intertrochanteric fracture patients undergoing operative treatment. BMC Musculoskelet Disord 2022;23:1-7.
27. Lin K-B, Yang N-P, Lee Y-H, Chan C-L, Wu C-H, Chen H-C, *et al*. The incidence and factors of hip fractures and subsequent morbidity in Taiwan: An 11-year population-based cohort study. PLoS One 2018;13:e0192388.
28. Engels A, Reber KC, Lindlbauer I, Rapp K, Büchele G, Klenk J, *et al*. Osteoporotic hip fracture prediction from risk factors available in administrative claims data–A machine learning approach. PLoS One 2020;15:e0232969.
29. Glinkowski W, Narloch J, Krasuski K, Śliwczyński A. The increase of osteoporotic hip fractures and associated one-year mortality in Poland: 2008–2015. J Clin Med 2019;8:1487.
30. Black DM, Delmas PD, Eastell R, Reid IR, Boonen S, Cauley JA, *et al*. Once-yearly zoledronic acid for treatment of postmenopausal osteoporosis. N Engl J Med 2007;356:1809-22.
31. Lorentzon M, Johansson H, Harvey N, Liu E, Vandenput L, McCloskey E, *et al*. Osteoporosis and fractures in women: The burden of disease. Climacteric 2022;25:4-10.
32. Pérez-Castrillón JL, Martín-Escudero JC, Manzanares PA, Sancho RC, Zamora SI, Alonso MG. Hypertension as a risk factor for hip fracture. Am J Hypertens 2005;18:146.
33. Schoofs MW, Van Der Klift M, Hofman A, De Laet CE, Herings RM, Stijnen T, *et al*. Thiazide diuretics and the risk for hip fracture. Ann Intern Med 2003;139:476-82.
34. Bai J, Gao Q, Wang C, Dai J. Diabetes mellitus and risk of low-energy fracture: A meta-analysis. Aging Clin Exp Res 2020;32:2173-86.
35. Shen Q, Ma Y. Impact of diabetes mellitus on risk of major complications after hip fracture: A systematic review and meta-analysis. Diabetol Metab Syndr 2022;14:51.
36. Hamann C, Goettsch C, Mettelsiefen J, Henkenjohann V, Rauner M, Hempel U, *et al*. Delayed bone regeneration and low bone mass in a rat model of insulin-resistant type 2 diabetes mellitus is due to impaired osteoblast function. Am J Physiol Endocrinol Metab 2011;301:E1220-8.
37. Wei R, Chen H, Zha M-L, Zhou Z. Diabetes and pressure ulcer risk in hip fracture patients: A meta-analysis. J Wound Care 2017;26:519-27.
38. De Waard EA, van Geel TA, Savelberg HH, Koster A, Geusens PP, Van Den Bergh JP. Increased fracture risk in patients with type 2 diabetes mellitus: An overview of the underlying mechanisms and the usefulness of imaging modalities and fracture risk assessment tools. Maturitas 2014;79:265-74.
39. Moayeri A, Mohamadpour M, Mousavi SF, Shirzadpour E, Mohamadpour S, Amraei M. Fracture risk in patients with type 2 diabetes mellitus and possible risk factors: A systematic review and meta-analysis. Ther Clin Risk Manag 2017;13:455-68.
40. Chiang CH, Liu CJ, Chen PJ, Huang CC, Hsu CY, Chen ZY, *et al*. Hip fracture and risk of acute myocardial infarction: A nationwide study. J Bone Miner Res 2013;28:404-11.
41. Chaudhry YP, MacMahon A, Rao SS, Sterling RS, Oni JK, Khanuja HS. Incidence, mortality, and complications of acute myocardial infarction with and without percutaneous coronary intervention in hip fracture patients. Injury 2021;52:2344-9.
42. Walter MF, Jacob RF, Jeffers B, Ghadanfar MM, Preston GM, Buch J, *et al*. Serum levels of thiobarbituric acid reactive substances predict cardiovascular events in patients with stable coronary artery disease: A longitudinal analysis of the PREVENT study. J Am Coll Cardiol 2004;44:1996-2002.
43. Vo TKD, de Saint-Hubert M, Morrhaye G, Godard P, Geenen V, Martens HJ, *et al*. Transcriptomic biomarkers of the response of hospitalized geriatric patients admitted with heart failure. Comparison to hospitalized geriatric patients with infectious diseases or hip fracture. Mech Ageing Dev 2011;132:131-9.
44. Kang J-H, Chung S-D, Xirasagar S, Jaw F-S, Lin H-C. Increased risk of stroke in the year after a hip fracture: A population-based follow-up study. Stroke 2011;42:336-41.
45. Bannan A, Shen R, Silvestry FE, Herrmann HC. Characteristics of adult patients with atrial septal defects presenting with paradoxical embolism. Catheter Cardiovasc Interv 2009;74:1066-9.
46. Tateishi Y, Iguchi Y, Kimura K, Kobayashi K, Shibazaki K, Eguchi K. Right-to-left shunts may be not uncommon cause of TIA in Japan. J Neurol Sci 2009;277:13-6.
47. Yuan J, Zhu G, Zhao Y, Huang J. Effect of hip fracture on prognosis of acute cerebral infarction. Clinics 2021;76:e3059.
48. Hjelholt TJ, Johnsen SP, Brynningsen PK, Pedersen AB. The interaction effect between previous stroke and hip fracture on postoperative mortality: A nationwide cohort study. Clin Epidemiol 2022:543-53.
49. Yeh K-T, Yu T-C, Lee R-P, Wang J-H, Liu K-L, Peng C-H, *et al*. Hepatic encephalopathy increases the risk of hip fracture: A nationwide cohort study. BMC Musculoskelet Disord 2020;21:1-6.
50. Montomoli J, Erichsen R, Gammelager H, Pedersen AB. Liver disease and mortality among patients with hip fracture: A population-based cohort study. Clin Epidemiol 2018;10:991-1000.
51. Keegan MT, Plevak DJ. Preoperative assessment of the patient with liver disease. Am J Gastroenterol ACG 2005;100:2116-27.
52. Tang C-H, Chou C-Y. Hip fracture in patients with non-dialysis

chronic kidney disease stage 5. Sci Rep 2021;11:20591.
53. Robertson L, Black C, Fluck N, Gordon S, Hollick R, Nguyen H, *et al*. Hip fracture incidence and mortality in chronic kidney disease: The GLOMMS-II record linkage cohort study. BMJ Open 2018;8:e020312.
54. Pimentel A, Urena-Torres P, Zillikens MC, Bover J, Cohen-Solal M. Fractures in patients with CKD—diagnosis, treatment, and prevention: A review by members of the European Calcified Tissue Society and the European Renal Association of Nephrology Dialysis and Transplantation. Kidney Int 2017;92:1343-55.
55. Beck GR Jr, Zerler B, Moran E. Phosphate is a specific signal for induction of osteopontin gene expression. Proc Natl Acad Sci 2000;97:8352-7.
56. Wu Z-J, Zhao P, Liu B, Yuan Z-C. Effect of cigarette smoking on risk of hip fracture in men: A meta-analysis of 14 prospective cohort studies. PLoS One 2016;11:e0168990.
57. Melhus H, Michaëlsson K, Holmberg L, Wolk A, Ljunghall S. Smoking, antioxidant vitamins, and the risk of hip fracture. J Bone Miner Res 1999;14:129-35.
58. Cusano NE. Skeletal effects of smoking. Curr Osteoporos Rep 2015;13:302-9.
59. Peter K, Jemma JC, John DW. The effects of smoking on bone health. Clin Sci 2007;113:233-41.
60. Wang S-M, Han K-D, Kim N-Y, Um YH, Kang DW, Na H-R, *et al*. Association of alcohol intake and fracture risk in elderly varied by affected bones: A nationwide longitudinal study. Psychiatry Investig 2020;17:1013.
61. Won S-D, Han C. Efficacy of the life goal-focused brief intervention among patients with alcohol use disorder: A preliminary study. Psychiatry Investig 2018;15:476.
62. Shiomoto K, Babazono A, Harano Y, Fujita T, Jiang P, Kim S-A, *et al*. Effect of body mass index on vertebral and hip fractures in older people and differences according to sex: A retrospective Japanese cohort study. BMJ Open 2021;11:e049157.
63. Bouxsein ML, Szulc P, Munoz F, Thrall E, Sornay-Rendu E, Delmas PD. Contribution of trochanteric soft tissues to fall force estimates, the factor of risk, and prediction of hip fracture risk. J Bone Miner Res 2007;22:825-31.
64. Aamodt G, Renolen R, Omsland T, Meyer H, Rabanal K, Søgaard A. Ethnic differences in risk of hip fracture in Norway: A NOREPOS study. Osteoporos Int 2020;31:1587-92.
65. Cauley JA, Chalhoub D, Kassem AM, Fuleihan GE-H. Geographic and ethnic disparities in osteoporotic fractures. Nat Rev Endocrinol 2014;10:338-51.
66. Kanis JA, Oden A, McCloskey EV, Johansson H, Wahl DA, Cooper C, *et al*. A systematic review of hip fracture incidence and probability of fracture worldwide. Osteoporos Int 2012;23:2239-56.
67. Patterson JA, Bennett RG. Prevention and treatment of pressure sores. J Am Geriatr Soc 1995;43:919-27.
68. Bucholz EM, Krumholz HM. Loneliness and living alone: Comment on "loneliness in older persons" and "living alone and cardiovascular risk in outpatients at risk of or with atherothrombosis". Arch Intern Med 2012;172:1084-5.
69. Perissinotto CM, Covinsky KE. Living alone, socially isolated or lonely—What are we measuring? J Gen Intern Med 2014;29:1429-31.
70. Dahl C, Holvik K, Meyer HE, Stigum H, Solbakken SM, Schei B, *et al*. Increased mortality in hip fracture patients living alone: A NOREPOS Study. J Bone Miner 2021;36:480-8.
71. Qu X, Zhang X, Zhai Z, Li H, Liu X, Li H, *et al*. Association between physical activity and risk of fracture. J Bone Miner 2014;29:202-11.
72. Lagerros YT, Hantikainen E, Michaelsson K, Ye W, Adami H-O, Bellocco R. Physical activity and the risk of hip fracture in the elderly: A prospective cohort study. Eur J Epidemiol 2017;32:983-91.
73. Gregg EW, Cauley JA, Seeley DG, Ensrud KE, Bauer DC. Physical activity and osteoporotic fracture risk in older women. Ann Intern Med 1998;129:81-8.
74. Court-Brown C, Clement N, Duckworth A, Biant L, McQueen M. The changing epidemiology of fall-related fractures in adults. Injury 2017;48:819-24.
75. Abe S, Kouhia R, Nikander R, Narra N, Hyttinen J, Sievänen H. Effect of fall direction on the lower hip fracture risk in athletes with different loading histories: A finite element modeling study in multiple sideways fall configurations. Bone 2022;158:116351.
76. Helgason B, Gilchrist S, Ariza O, Chak J, Zheng G, Widmer R, *et al*. Development of a balanced experimental–computational approach to understanding the mechanics of proximal femur fractures. Med Eng Phys 2014;36:793-9.
77. Johannesdottir F, Allaire B, Bouxsein ML. Fracture prediction by computed tomography and finite element analysis: Current and future perspectives. Curr Osteoporos Rep 2018;16:411-22.
78. Chinoy MA, Javed S. Frequency of vertebral fractures in patients presenting with hip fractures. Pak J Med Sci 2020;36:S44.
79. Black DM, Arden NK, Palermo L, Pearson J, Cummings SR. Prevalent vertebral deformities predict hip fractures and new vertebral deformities but not wrist fractures. Study of Osteoporotic Fractures Research Group. J Bone Miner Res 1999;14:821-8.
80. Li H-L, Shen Y, Tan L-H, Fu S-b, Dai R-C, Yuan L-Q, *et al*. Relationship between bone mineral density and fragility fracture risk: A case-control study in Changsha, China. BMC Musculoskelet Disord 2021;22:1-8.
81. Li Y, Lin J, Cai S, Yan L, Pan Y, Yao X, *et al*. Influence of bone mineral density and hip geometry on the different types of hip fracture. Bosn J Basic Med Sci 2016;16:35.
82. Kanis JA, Borgstrom F, De Laet C, Johansson H, Johnell O, Jonsson B, *et al*. Assessment of fracture risk. Osteoporos Int 2005;16:581-9.
83. Svensson J, Ohlsson C, Karlsson M, Lorentzon M, Lewerin C, Mellström D. Subclinical hyperthyroidism is associated with increased risk of vertebral fractures in older men. Osteoporos Int 2021;32:2257-65.
84. Murphy E, Gluer CC, Reid DM, Felsenberg D, Roux C, Eastell R, *et al*. Thyroid function within the upper normal range is associated with reduced bone mineral density and an increased risk of nonvertebral fractures in healthy euthyroid postmenopausal women. J Clin Endocrinol Metab 2010;95:3173-81.
85. Roef G, Lapauw B, Goemaere S, Zmierczak H, Fiers T, Kaufman J-M, *et al*. Thyroid hormone status within the physiological range affects bone mass and density in healthy men at the age of peak bone mass. Eur J Endocrinol 2011;164:1027-34.
86. Álvarez MN, Bonnardeaux PL-D, Thuissard I, Sanz-Rosa D, Muñana EA, Galindo RB, *et al*. Grip strength and functional recovery after hip fracture: An observational study in elderly population. Eur Geriatr Med 2016;7:556-60.
87. Han J, Kim C-H, Kim JW. Handgrip strength effectiveness and optimal measurement timing for predicting

functional outcomes of a geriatric hip fracture. Sci Rep 2022;12:20600.
88. Chang C-M, Lee C-H, Shih C-M, Wang S-P, Chiu Y-C, Hsu C-E. Handgrip strength: A reliable predictor of postoperative early ambulation capacity for the elderly with hip fracture. BMC Musculoskelet Disord 2021;22:1-6.
89. Mortimore E, Haselow D, Dolan M, Hawkes WG, Langenberg P, Zimmerman S, *et al*. Amount of social contact and hip fracture mortality. J Am Geriatr Soc 2008;56:1069-74.
90. Ivers RQ, Norton R, Cumming RG, Butler M, Campbell AJ. Visual impairment and hip fracture. Am J Epidemiol 2000;152:633-9.
91. Liao P-S, Chiu C-C, Fu Y-H, Hsia C-C, Yang Y-C, Lee K-F, *et al*. Incidence of hip fractures among patients with chronic otitis media: The real-world data. Medicina 2022;58:1138.
92. Dotevall A, Krantz E, Barrenäs ML, Landin-Wilhelmsen K. Hearing and balance exceed initial bone mineral density in predicting incident fractures: A 25-year prospective observational study in menopausal women with osteoporosis. JBMR Plus 2022;6:e10551.
93. Friedman SM, Menzies IB, Bukata SV, Mendelson DA, Kates SL. Dementia and hip fractures: Development of a pathogenic framework for understanding and studying risk. Geriatr Orthopa Surg Rehabil 2010;1:52-62.
94. Zhao Y, Shen L, Ji H-F. Alzheimer's disease and risk of hip fracture: A meta-analysis study. ScientificWorldJournal 2012;2012:872173.
95. Chu Y-W, Chen W-P, Yang AC, Tsai S-J, Hu L-Y, Lee S-C, *et al*. Hip, vertebral, and wrist fracture risks and schizophrenia: A nationwide longitudinal study. BMC Psychiatry 2022;22:1-10.
96. Kao F-C, Hsu Y-C, Lin C-FJ, Lo Y-Y, Tu Y-K. Corticosteroid is associated with both hip fracture and fracture-unrelated arthropathy. PLoS One 2017;12:e0169468.
97. Huyke-Hernández FA, Parashos SA, Schroder LK, Switzer JA. Hip fracture care in Parkinson disease: A retrospective analysis of 1,239 patients. Geriatr Orthop Surg Rehabil 2022;13:21514593221118225.
98. Coomber R, Alshameeri Z, Masia AF, Mela F, Parker MJ. Hip fractures and Parkinson's disease: A case series. Injury 2017;48:2730-5.
99. Invernizzi M, Carda S, Viscontini GS, Cisari C. Osteoporosis in Parkinson's disease. Parkinsonism Relat Disord 2009;15:339-46.
100. Mazzucchelli R, Fernandez EP, Crespí-Villarías N, Quirós-Donate J, Vadillo AG, Espinosa M, *et al*. Trends in hip fracture in patients with rheumatoid arthritis: Results from the Spanish National Inpatient Registry over a 17-year period (1999–2015). TREND-AR study. RMD Open 2018;4:e000671.
101. Rocha AFB, Sá MVBDO, Elihimas UF. Hyponatremia in elderly patients with fragility fractures of the proximal femur: A cross-sectional study. J Bras Nefrol 2019;41:518-25.
102. Ayus JC, Fuentes N, Go AS, Achinger SG, Moritz ML, Nigwekar SU, *et al*. Chronicity of uncorrected hyponatremia and clinical outcomes in older patients undergoing hip fracture repair. Front Med 2020;7:263.
103. Yao P, Bennett D, Mafham M, Lin X, Chen Z, Armitage J, *et al*. Vitamin D and calcium for the prevention of fracture: A systematic review and meta-analysis. JAMA Netw Open 2019;2:e1917789.
104. Bolland MJ, Grey A, Avenell A. Effects of vitamin D supplementation on musculoskeletal health: A systematic review, meta-analysis, and trial sequential analysis. Lancet Diabetes Endocrinol 2018;6:847-58.
105. Black DM, Cauley JA, Wagman R, Ensrud K, Fink HA, Hillier TA, *et al*. The ability of a single BMD and fracture history assessment to predict fracture over 25 years in postmenopausal women: The study of osteoporotic fractures. J Bone Miner Res 2018;33:389-95.
106. Kanis J, Johansson H, Odén A, Johnell O, De Laet C, Eisman J, *et al*. A family history of fracture and fracture risk: A meta-analysis. Bone 2004;35:1029-37.
107. Toth E, Banefelt J, Åkesson K, Spångeus A, Ortsäter G, Libanati C. History of previous fracture and imminent fracture risk in Swedish women aged 55 to 90 years presenting with a fragility fracture. J Bone Miner Res 2020;35:861-8.
108. Oughli HA, Chen G, Miller JP, Nicol G, Butters MA, Avidan M, *et al*. Cognitive improvement in older adults in the year after hip fracture: Implications for brain resilience in advanced aging. Am J Geriatr Psychiatry 2018;26:1119-27.
109. Inoue T, Maeda K, Nagano A, Shimizu A, Ueshima J, Murotani K, *et al*. Undernutrition, sarcopenia, and frailty in fragility hip fracture: Advanced strategies for improving clinical outcomes. Nutrients 2020;12:3743.
110. Choi J-Y, Cho K-J, Kim S-w, Yoon S-J, Kang M-g, Kim K-i, *et al*. Prediction of mortality and postoperative complications using the hip-multidimensional frailty score in elderly patients with hip fracture. Sci Rep 2017;7:1-8.
111. Inoue T, Misu S, Tanaka T, Kakehi T, Kakiuchi M, Chuman Y, *et al*. Frailty defined by 19 items as a predictor of short-term functional recovery in patients with hip fracture. Injury 2019;50:2272-6.
112. Jorissen RN, Lang C, Visvanathan R, Crotty M, Inacio MC. The effect of frailty on outcomes of surgically treated hip fractures in older people. Bone 2020;136:115327.
113. Low S, Wee E, Dorevitch M. Impact of place of residence, frailty and other factors on rehabilitation outcomes post hip fracture. Age Ageing 2021;50:423-30.
114. Bacon WE, Hadden WC. Occurrence of hip fractures and socioeconomic position. J Aging Health 2000;12:193-203.
115. Zingmond D, Soohoo N, Silverman S. The role of socioeconomic status on hip fracture. Osteoporos Int 2006;17:1562-8.
116. Wang M-C, Dixon LB. Socioeconomic influences on bone health in postmenopausal women: Findings from NHANES III, 1988–1994. Osteoporos Int 2006;17:91-8.
117. Brenn T, Ytterstad E. Increased risk of death immediately after losing a spouse: Cause-specific mortality following widowhood in Norway. Prev Med 2016;89:251-6.