Archives of Osteoporosis (2019) 14:57
https://doi.org/10.1007/s11657-019-0600-7

ORIGINAL ARTICLE

Unhealthy lifestyles are associated with the increased risk of low-energy fracture in Chinese men ≥ 50 years, a population-based survey

Guobin Liu[1,2,3] · Yansen Li[1,2] · Yanbin Zhu[1,2] · Wei Chen[1,2] · Xin Xing[2] · Jiashen Shao[1,2] · Song Liu[1,2] · Hongzhi Lv[2] · Chenni Ji[1,2] · Xiaolin Zhang[4] · Yingze Zhang[1,2,5]

Received: 16 October 2018 / Accepted: 14 April 2019

ABSTRACT

Purpose This study aims to investigate the incidence of low-energy fractures in men aged 50 years and older in China and to explore associated risk factors.

Methods All the relevant data were available from the China National Fracture Survey (CNFS), which was a cross-sectional survey carried out in eight Chinese provinces (municipalities) between January and May 2015.

Results Through 2014, 76,687 men above 50 years participated in this study and 223 participants had low-energy fractures, indicating the incidence rate 290.8 (95%CI, 252.7–328.9)/100,000 men. Over 80% of the fractures occurred at home and on the common road. The fracture incidence rate presented a significant rising trend with advanced age ($p = 0.039$). Current smoking, alcohol overconsumption, insufficient sleep duration, and history of past fracture were identified as significant risk factors associated with low-energy fracture ($p < 0.05$).

Conclusions These results will assist the decisions regarding allocation of healthcare provision to populations of greatest need and aid the design and implementation of strategies to reduce fracture incidence. Accordingly, individuals should be encouraged to reduce alcohol consumption, immediately quit smoking, and get sufficient sleep, especially in those with a history of past fracture. In addition, primary preventives especially home prevention should be emphasized.

Keywords Epidemiology · Low-energy fracture · Risk factor · Population-based

Guobin Liu, Yansen Li, Yanbin Zhu and Wei Chen contributed equally to this work.

This study is registered with the Chinese Clinical Trial Registry, number ChiCTR-EPR-15005878.

✉ Yingze Zhang
drzhang2013@126.com

Guobin Liu
drguobin2018@126.com

Yansen Li
490700677@qq.com

Yanbin Zhu
zhuyanbin111@126.com

Wei Chen
drchenwei1981@gmail.com

Xin Xing
64050128@qq.com

Jiashen Shao
lancetshao@126.com

Song Liu
helanghappy@126.com

Hongzhi Lv
190099199@qq.com

Chenni Ji
396464018@qq.com

Xiaolin Zhang
807210221@qq.com

Extended author information available on the last page of the article

Published online: 29 May 2019

Introduction

Osteoporosis is a chronic, multifactorial bone disease, characterized by an increased rate of bone turnover with resultant more bone resorption than bone formation [1]. The prevalence of osteoporosis was estimated to be 33–40% in postmenopausal white women and lower in middle-aged and elderly men [2, 3]. Relative to osteoporosis itself, the resultant low-energy fracture is more a social concern, which significantly increases the risk of morbidity and mortality for sufferers and imposes a substantial social and economic burden. According to the literature reports, over 65% of all the fractures were related to osteoporosis or caused by low-energy trauma [4, 5]. In 2001, the US National Institute of Health (NIH) revised the definition of osteoporosis to include qualitative parameters related to low-energy fractures [6].

There is a striking difference in lifetime risk of osteoporosis-related fracture between women since menopause and men of the similar age, largely explained by the physiology structure and estrogen level. As was reported, approximately 35–50% of women had to suffer at least one osteoporosis-related fracture during their remaining lifetime since 50 years, and in men, the risk was 15–20% [7, 8]. Compared to treatment of these fragile fractures, using clinical factors to identify individuals at higher risk is undoubtedly the most simple and cost-effective method of reducing the incidence rate. Furthermore, with age, bone mineral density, and several clinical risk factors applied, the FRAX® tool is developed and used together with bone densitometry in various countries to evaluate future 10-year fracture risk, thus making it possible to individualize treatment for each patient [9, 10]. By far, there were sufficient studies conducted to develop the fragile fracture prediction model in postmenopausal women, and these clinical risk factors generally included advanced age, early menopause, a sedentary lifestyle, diabetes, recurrent falls, and a family history of fragile fracture [3, 11–13]. However, for men, either the quantity, width, or the depth of these epidemiologic researches about osteoporosis-related fractures was not comparable to women.

In China, approximately 1.27 million individuals had at least one fragile fracture per year, and one third of these fractures occurred in men aged 50 years and older [4]. It is predictable that this figure will increase dramatically in the next decades, as China gradually enters the aging society. Previous studies in various countries reported the variant incidence rates of fragile fractures and have identified some risk factors, but most of them only focus on one or several medical centers, a region, a certain group of population, or a certain fracture site [14, 15], which might be compromised by the small sample size and selective biases. Additionally, these results might not be applicable to our Chinese populations due to different ethnic origins, cultural practices, and individual lifestyles, thus making it impractical and even counterproductive to use these results to develop bone-health tragedies in China. Currently, there remains lack of population-based epidemiologic survey on the low-energy fractures in middle-aged and elderly men.

Given that circumstance, we conducted this study with the data available from the China National Fracture Survey (CNFS) database with two aims: (1) to investigate the incidence of low-energy fracture in men aged 50 years and older and (2) to identify independent socioeconomic, geographical factors and individual lifestyles associated with low-energy fractures.

Subjects and methods

Chinese National Fracture Survey

Between January and May 2015, we conducted the Chinese National Fracture Survey (CNFS), which was a retrospective cross-sectional survey carried out in eight Chinese provinces (municipalities). Details of sampling methods and participant inclusion were described elsewhere [4]. Briefly, stratified multistage cluster randomized sampling method was used to recruit subjects in this survey. Within each targeted province (municipalities), sampling was done separately in urban and rural areas. Households were calculated and selected. Only members of eligible families living in the current residence for 6 months or longer were invited for face-to-face interview with our trained research team members. A standardized questionnaire was administrated for data collection.

Data collection and fracture ascertainment

These data included age, sex, ethnic origin, residence, occupation, lifestyles, dietary patterns, and so on. Individuals who had traumatic fractures (fractures due to pathology and metastases were excluded) between 1 January 1 and 31 December, 2014, then answered a more detailed accessory questionnaire regarding the fracture occurrence date, place, and injury mechanism. In addition, they were asked to provide medical data of the reported fractures, including radiographs, diagnostic reports, and medical records. And if these data were not available, the survey team paid for obtaining a new radiograph of their reported fracture site at a local hospital for reevaluation.

Eight quality control teams (one for each province) were established to check for omissions and errors of the randomized questionnaires (approximately 10% of all questionnaires). The CNFS was approved by the Institutional Review Board of the 3rd Hospital of Hebei Medical University. Written informed consent was obtained from each participant before data collection.

A total of 512,187 valid questionnaires from the pilot survey (95%) and the subsequent supplementary survey (5%) were collected for data analysis.

Current study

All methods in this study were performed in accordance with the STROCSS (Strengthening the Reporting of Cohort Studies in Surgery) guidelines.

Low-energy fracture was defined as a fracture that was caused by slip, trip, or fall from standing height. Fractures due to high-energy trauma like traffic injuries, fall from height, crush injuries, and some mechanical injuries were excluded from this study. Finally, 76,687 participants ≥ 50 years could provide eligible data for analysis and were included in this study. During 2014, 426 participants had at least one fracture for any reason (high-or low-energy trauma) and 223 men (case group) had fragile fractures caused by low-energy trauma. The remaining 76,261 men without any fracture either from high- or low-energy trauma were defined as control group.

Variables of interest

These variables included living areas (rural or urban), regions (eastern, central or western), latitude zone (20°–29.9°, 30°–39.9°, or 40°–49.9°), age, height, weight and accordingly calculated body mass index (BMI), ethnic origins, occupation, educational level (illiteracy, primary, junior, high school, or more), tobacco use (current or not), alcohol consumption, dwelling place (ground floor, > 2nd floor with or without elevator), living house facing the sun (yes or not), average sleeping duration per day, history of any past fracture (yes or not), living situation (alone or with others), and supplementation of calcium or vitamin D or both (yes or not).

Participants were also asked to recall the average frequency they consumed milk and dairy products (cheese, fermentation milk or yoghourt, and others), meat and meat products (fish, mutton, beef, rib chop, pork and hams, sausages, and others), bean and soy products (dried bean curd or sticks, doufu, dried tofu, and others), tea (black, green, white, scented, and others), carbonate beverages (Coca Cola, sprite, Pepsi Cola, and similar), and coffee (instant or non-instant) during the through 2014 year or the past year before their reported fracture occurrence. Possible responses included more than once a day, once a day, less than once a day but more than once a week, once a week, less than once a week, and never. To facilitate analyses, responses were classified into four categories: ≥ 1 serving/day, 1–6 servings/week, < 1/week and never. Regarding coffee, due to its very low frequency of intake, two categories were classified, current or not.

Specifically, the BMI was grouped based on the reference criteria suited to Chinese populations: underweight, < 18.5 kg/m^2; normal, 18.5–23.9 kg/m^2; overweight, 24–27.9 kg/m^2; obesity, ≥ 28 kg/m^{24}. Participants who smoked more than 1 time or at least 10 cigarettes per week for at least 6 months were defined as current cigarette smokers [16]. Alcohol drinking was defined as consumption of at least one drink during the past 1 month; alcohol overconsumption is defined as drinking five or more drinks, or self-reported drunkenness on the same occasion or at least 1 day in the past 1 month prior to the survey [17]. Similarly within this time window, supplementation of calcium or vitamin D or both was defined as positive (yes) if participants acknowledged they took these medications for at least 1 month; otherwise, as negative (no).

Statistical analysis

We estimated the incidence of low-energy fractures for subgroups by age (every 5 years as a category) and educational level, and the trend of incidence among subgroups was tested by the univariate logistic regression model. We also estimated the incidence for subgroups by ethnic origin, urbanization, region, and occupation, and the difference among subgroups for each variable was evaluated by chi-square test.

We used a two-step modeling strategy to adjust for potential confounding. Firstly, we used the bivariate logistic regression model to investigate the relationship between potential variables and the risk of low-energy fractures. Ordered variables as age, weight, height, BMI, educational level, intake frequency of milk, meat and products, bean and soy products, tea and carbonate beverages, latitude categories were entered into the univariate model as ordered categorical variables and trend test was performed. Unordered or binary variables including educational level, urbanization (urban or rural), region, ethnic group, sleep duration per day, history of past fracture, supplementation of calcium or vitamin D or both, dwelling place, living house, living status, were tested by the chi-square test. Secondly, we entered those variables identified as significant or approximately significant ($P < 0.20$) in bivariate analyses into the multivariate logistic regression models, to identify the associated risk factors and calculate adjusted odd ratio (OR) values and corresponding 95% confidence interval (95% CI). A stepwise backward-elimination approach was used to exclude confounding covariates from the final models. Covariates were retained in the final model if the p value was ≤ 0.10 and $p < 0.05$ was set as the statistical significance level. The Hosmer–Lemeshow test was used to examine goodness-of-fit of the final model, and a P value > 0.05 indicated an acceptable fitness. SPSS 19.0 was used to perform all the analyses (SPSS Inc., Chicago, Illinois, USA).

Results

Over 50% (116/223) of the total fractures occurred at home, followed by on the common road (68, 31.0%) and workplace (14, 6.0%) (Fig. 1). The incidence rate of low-energy fractures was 290.8 (95%CI, 252.7–328.9) per 100,000 person-year in men aged 50 years and older. There was no significant difference in incidence between those of Han ethnicity and others

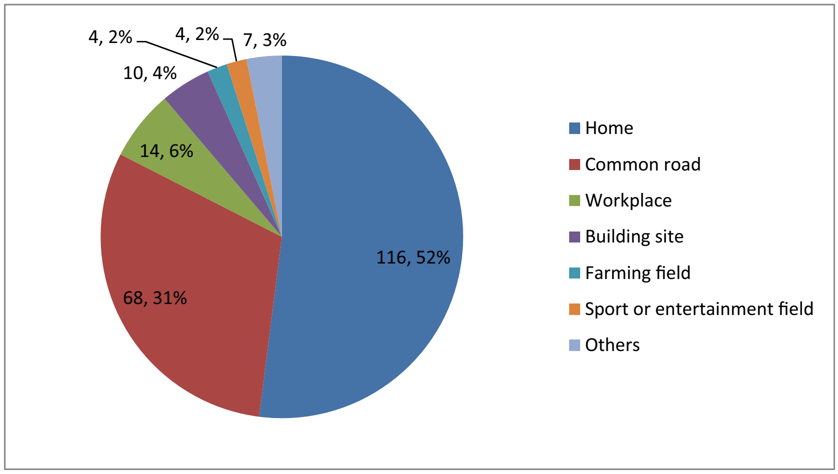

Fig. 1 Places where low-energy fracture occurred in 2014

($p = 0.575$), similarly as to urbanization level ($p = 0.575$), ethnic origin ($p = 0.399$), region ($p = 0.991$), latitude ($p = 0.619$), and occupation ($p = 0.325$). There was significant difference in incidence of low-energy fracture among age categories ($p = 0.039$) and educational level ($p = 0.049$). Stratified by age, individuals above 80 years had the highest incidence rate that was 400.9 (95%CI, 204.9–597.0)/100,000 person-year. Stratified by education, the uneducated individuals had the higher incidence of fracture, which was 354.1 (278.9–429.2)/100,000 person-year. These data are listed in Table 1.

Univariate analysis

In men, there was significant or approximately significant difference ($p < 0.20$) in incidence of low-energy fracture between case and control groups, in terms of educational level ($p = 0.113$), smoking status ($p = 0.051$), alcohol consumption ($p < 0.001$), living status ($p = 0.133$), history of past fracture ($p < 0.001$), and sleep duration per day ($p < 0.001$). The detailed data are shown in Table 2.

Multivariate analysis

After adjustment for confounding variables, current smoking (OR, 1.88; 95%CI, 1.05–3.14), alcohol overconsumption (OR, 3.95; 95%CI, 1.77–5.98), history of past fracture (OR, 2.62; 95%CI, 1.86–3.64), and sleep duration< 7 h/day (OR, 2.79; 95%CI, 1.83–4.26) were identified to be significantly associated with low-energy fracture. The detailed data were listed in Table 3. The results of Hosmer–Lemeshow test showed the inadequate fitness, but the significance approached to statistical level ($X^2 = 6.555$, $P = 0.178$).

Discussion

Currently, this is the most comprehensive, population-based study of low-energy fractures for middle-aged and elderly men in China. The incidence was 290.8 per 100,000 persons in 2014, which, by extension, suggests that roughly 420 thousand middle-aged and elderly Chinese men had at least one low-energy fracture. We also observed a significantly increased trend of incidence of low-energy fracture with age ($p = 0.039$). After adjustment for confounding variables, current smoking, alcohol overconsumption, sleep duration < 7 h/day, and history of past fracture were identified as independent risk factors associated with the increased risk of low-energy fractures.

In the worldwide, the fracture incidence was reported to be substantially diverse, and geography, ethnicity, and socioeconomic status have been demonstrated as predominant factors leading to this diversity [18–20]. Due to the substantial costs from manpower and materials and financial resources, it is less possible to perform a national population-based questionnaire survey. A recent UK study investigated the incidence of fragile fractures (hip, spine, rib, humerus, radius/ulna or pelvis) as 384 per 100,000 person-years in men aged 50 years and older, with data available from Clinical Practice Research Datalink (CPRD) during 1988–2012 [21]. A US study used comprehensive data resources of the Rochester Epidemiology Project and estimated the incidence rate of any fracture was 2704 per 100,000 person-years for residents in Olmsted County [22]. In other studies from western developed countries [23–25], authors also reported the higher incidence of fracture, about 1.5–3 times as ours in this study. In contrast, the reported incidence of osteoporosis-related fractures in neighboring Asian countries like Japan [26, 27] and South Korea [28, 29] were comparable to ours, which demonstrated the importance of the geography, ethnicity, and social-economic status in the incident fractures.

Multivariate logistic regression analysis was performed to identify the factors associated with the occurrence of low-energy fractures. Four independent risk factors were identified, and three of them referred to the unhealthy lifestyles, including smoking, alcohol overconsumption, and insufficient daily sleep duration (< 7 h/day). Kanis et al. [30] pooled the data from previous original studies and found current smoking

Table 1 National incidence of low-energy fractures in Chinese men ≥50 years, stratified by demographic, socioeconomic, and geographic factors in 2014

Items	Case	Sample	Incidence/100,000 person-years, 95% CI			
			Incidence	Lower limit	Upper limit	*p*
Individuals	223	76,687	290.8	252.7	328.9	
Age						0.039[a]
50–54	47	19,663	239.0	170.8	307.3	
55–59	37	12,612	293.4	199.0	387.8	
60–64	43	16,282	264.1	185.3	342.9	
65–69	38	10,870	349.6	238.6	460.5	
70–74	24	8451	284.0	170.5	397.4	
75–80	18	4818	373.6	201.3	545.9	
80+	16	3991	400.9	204.9	596.9	
Ethnic origin						0.575[b]
Han nationality	211	71,861	293.6	254.1	333.2	
Other nationalities	12	4826	248.7	108.1	389.2	
Urbanization						0.399[b]
Urban area	83	30,668	270.6	212.5	328.8	
Rural area	140	46,019	304.2	253.9	354.5	
Region						0.991[a]
East	104	35,418	293.6	237.3	350.0	
Central	43	14,876	289.1	202.8	375.3	
West	76	26,393	288.0	223.3	352.6	
Latitude categories						0.619
20–29.9° N	71	26,723	265.7	204.0	327.4	
30–39.9° N	129	42,007	307.1	254.2	360.0	
40–49.9° N	23	7957	289.1	171.1	407.1	
Education						0.049[a]
Illiterate	85	24,006	354.1	278.9	429.2	
Primary school	78	28,192	276.7	215.4	338.0	
Junior high school	50	21,352	234.2	169.3	299.0	
Senior high school or above	10	3137	318.8	121.5	516.0	
Occupation						0.325[b]
Office worker	19	6784	280.1	154.3	405.8	
Farmer	74	27,187	272.2	210.3	334.1	
Manual worker	46	17,711	259.7	184.8	334.7	
Retired	43	14,842	289.7	203.2	376.2	
Unemployed	29	6758	429.1	273.3	585.0	
Other	12	3405	352.4	153.4	551.5	

[a] *p* for the trend test

[b] *p* value for difference test

increased risk of any fracture by 25%, and of osteoporosis-related fracture by 29%, compared to the non-smoking. The potential mechanism was suggested to be BMD alteration by smoking, through lowering the 25-hydroxyvitamin D level, impairing the parathyroid [31] and reducing body weight by suppressing the appetite of smokers [32]. Excess alcohol consumption was another significant risk factor for osteoporosis-related fracture, with alcohol-related metabolic effects and accidental falls being the primary contributing factors [33, 34]. Scholes et al [33] found men consuming 4–8 units and > 8 units of alcohol on the heaviest drinking day in the past week had the 1.18 to 1.65-time increased risk of lifetime fractures. Stone et al. [35] and Holmberg et al. [36] reported the adverse effects of insufficient sleep on the risk of fracture in men or women and suggested frequent fall caused by insufficient sleep was the direct reason for fracture occurrence. Accordingly, public health strategies that focus on reducing alcohol consumption and encouraging individuals to quit

Table 2 Detailed results of univariate analysis for variables of interest in men ≥ 50 years

Variables	Case (n = 223, %)	Control (n = 76,261, %)	p value
Latitude			0.611
20–29.9°	71 (31.8)	26,602 (34.9)	
30–39.9°	129 (57.8)	41,741 (54.7)	
40–49.9	23 (10.4)	7918 (10.4)	
Region			0.991
Eastern	104(46.6)	35,223(46.2)	
Middle	43(19.3)	14,807(19.4)	
Western	76(34.1)	26,231(34.4)	
Urbanization			0.827
Rural area	83(37.2)	30,521(40)	
Urban area	140(62.8)	45,740(60)	
Age (year)			0.386
50–59	84(37.7)	32,091(42.1)	
60–69	81(36.3)	26,987(35.4)	
70–79	42(18.8)	13,215(17.3)	
80+	16(7.2)	3968(5.2)	
Ethnicity			0.573
Han	211(94.6)	71,458(93.7)	
Other	12(5.4)	4803(6.3)	
*Height (cm)			0.242
< 160	9 (4.0)	3569 (4.7)	
160–169	102 (45.7)	30,149 (39.5)	
170–179	105 (47.1)	40,082 (52.6)	
≥ 180	7 (3.1)	2461 (3.2)	
#Weight (kg)			0.246
< 50	4 (1.8)	1049 (1.4)	
50–59	32 (14.3)	11,675 (15.3)	
60–69	113 (50.7)	35,100 (46.0)	
70–79	59 (26.5)	21,697 (28.5)	
80–89	14 (6.3)	5637 (7.4)	
≥ 90	1 (0.4)	1103 (1.4)	
BMI			0.257
18.5–23.9	145(65)	46,785(61.3)	
24–27.9	59(26.5)	23,403(30.7)	
≥ 28	7(3.1)	3228(4.2)	
< 18.5	12(5.4)	2845(3.7)	
Education			0.113
Illiterate	85(38.1)	23,849(31.3)	
Primary school	78(35)	28,032(36.8)	
Junior high school	50(22.4)	21,259(27.9)	
Senior high school or above	10(4.5)	3121(4.1)	
Occupation			0.322
Unemployed	29(13)	6708(8.8)	
Office worker	19(8.5)	6747(8.8)	
Manual worker	46(20.6)	17,607(23.1)	
Farmer	74(33.2)	27,037(35.5)	
Retired	43(19.3)	14,773(19.4)	
Other	12(5.4)	3389(4.4)	
Meat and product			0.451
Never	0(0)	15(0)	
≥ 1/day	106(47.5)	37,601(49.3)	
1–6/week	72(32.3)	22,767(29.9)	
< 1/week	45(20.2)	15,878 (20.9)	
Milk intake			0.962
Never	107(48)	37,191(48.8)	
≥ 1/day	36(16.1)	11,591(15.2)	
1–6/week	29(13)	10,496(13.8)	
< 1/week	35(15.7)	16,983(22.3)	
Bean products			0.618
Never	0(0)	532(0.7)	
≥ 1/day	44(19.7)	15,330(20.1)	
1–6/week	98(43.9)	34,323(45)	
< 1/week	81(36.3)	26,076(34.2)	
Cigarette smoking			0.051
Past, less, or never	98(43.9)	38,507(50.5)	
Current	125(56.1)	37,754(49.5)	
Alcohol consumption			< 0.001
< 1 time/month or never	60(26.9)	34,910 (45.8)	
1 to 4 times/month	116 (52.0)	36,832 (48.3)	
Overconsumption	47 (21.1)	4519 (5.9)	
Living alone			0.133
No	220(98.7)	75,819(99.4)	
Yes	3(1.3)	442(0.6)	
Carbonate beverages			0.726
Never	181(81.2)	61,172(80.2)	
≥ 1/day	1(0.4)	358(0.5)	
1–6/week	7(3.1)	1625(2.1)	
< 1/week	34(17.1)	13,106(17.2)	
Coffee			0.546
No	215(96.4)	74,044(97.1)	
Yes	8(3.6)	2217(2.9)	
Tea			0.909
Never	112(50.2)	37,192(48.8)	
≥ 1/day	73(32.7)	25,340(33.2)	
1–6/week	18(8.1)	7076(9.3)	
< 1/week	20(8.9)	6623(8.7)	
House facing the sun			0.717
No	3(1.3)	833(1.1)	
Yes	220(98.7)	75,428(98.9)	
Living circumstance			0.553
Ground floor	93(41.7)	31,663(41.5)	
≥ 2nd floor with elevator	110(49.3)	39,135(51.3)	
≥ 2nd floors without elevator	20(9)	5463(7.2)	
Calcium or vitamin D or both			0.417
No	204(91.5)	68,509(89.8)	
Yes	19(8.5)	7752(10.2)	
Sleep time (hours)/day			< 0.001
≥ 7	64(28.7)	38,936(51.1)	
< 7	159(71.3)	37,325(48.9)	
Previous history of fracture			< 0.001
No	198(88.8)	73,327(96.2)	
Yes	25(11.2)	2934(3.8)	

smoking and to improve sleep quality and duration, should particularly be implemented in China to reduce fracture risk.

History of past fracture as a risk factor for low-energy fracture was well-established in literature, and in this study, individuals having history of fracture had the increased 2.8 time risk of low-energy fracture. Kanis et al [37] conducted a meta-analysis to pool the results from original studies and found that, a previous fracture history significantly increased the risk of any fracture by 1.86 times and the risk ration was similar for osteoporosis-related fractures. Kanis et al. [37] also found low BMD could only explain 8% of the risk for any fracture, indicating the negative effect imposed by previous history fracture was almost completely independent of BMD. In contrast, external factor as increased tendency to fall after the first

Table 3 Risk factors associated with low-energy fractures in men above 50 years after adjustment for confounding variables

Variables	OR	95% CI		*P*
		Lower limit	Upper limit	
Current smoking	1.88	1.05	3.14	0.044
Alcohol consumption				
< 1 time/month or never	Reference			
1 to 4 times/month	1.38	0.63	1.94	0.572
Overconsumption	3.95	1.77	5.98	< 0.001
Sleep time < 7 h/day	2.79	1.83	4.26	< 0.001
History of previous fracture	2.62	1.86	3.64	< 0.001

fracture was more a contributor to the secondary fracture [37, 38]. Therefore, compared to mineral substantial supplementation (mainly calcium), prevention of falls through muscle strength and postural balance exercise might be a more effective and advisable method. For example, moderate or intense weight-bearing exercises as walking, running, and Tai Chi Chuan are beneficial both for bone development and muscle coordination [39, 40].

Strengths and limitations

The study strengths included the population-based design, stratified multistage cluster randomized sampling method for recruiting subjects and a large range of covariates for adjustment. Also, patients' self-report initially and further confirmed by their providing clinical or radiographic data were used for ascertainment of fracture case, which increased the accuracy of diagnosis.

Despite that, there are several limitations that should be mentioned. Firstly, in this study, some selection and recall bias was inevitable, due to its retrospective nature. The study could not capture information about fracture cases in which the individual had died, because some fracture like hip fracture had a high fatality rate. Additionally, asymptomatic or subclinical fracture cases like vertebral compression fracture was potentially underreported or unreported. Therefore, the incidence rate of low-energy fracture was underestimated, overall. Secondly, due to the cross-sectional design, this study could not provide any longitudinal information and did not allow the assessment of the causal inference. Thirdly, despite so many covariates included for adjustment in multivariate analysis, the residual confounding by measuring error or unmeasured confounders still remains. For example, change of weight and height since young age, use of medications (glucocorticoids, antidepressants), and chronic diseases (rheumatoid arthritis, diabetes) were generally related to osteoporosis, fragile fractures, or propensity to fall; the body mass density (BMD) is a most important intrinsic factor that was associated with occurrence of fracture, but relevant information was not available. Fourth, due to the ethnic, racial, socioeconomic, and geographical factors primarily influencing the incidence and prevalence of osteoporosis or related fracture, the results of this study might not be generalizable to other countries or regions.

Conclusion

This study provided detailed epidemiologic characteristics of the low-energy fractures in Chinese middle-aged and elderly men, including the incidence, fracture occurrence places, and associated risk factors. These results could be used as updated clinical evidence base for national healthcare planning and preventive efforts in China. Based on these results, individuals especially those with history of any past fracture should be encouraged to reduce alcohol consumption, quit smoking, and get a high-quality sleep, to reduce the incidence of low-energy fractures. In addition, primary preventives especially home prevention should also be emphasized.

Acknowledgments We are grateful to Q Zhang and H Wang of the Department of Orthopedics, and to X Zhang of the Department of statistics and epidemiology for their kind assistance.

Authors' contribution Y Zhang conceived the idea for the study. Y Zhang, Y Zhang, YL, YZ, SL, WC, and HL and designed the study. JS, YZ and XZ performed the statistical analyses. XX, YL, YZ, and CJ prepared the figures and tables. YL, YZ, JS, SL, WC, HL, and CJ interpreted the data and contributed to preparation of the manuscript. GL, YL, and YZ contributed equally to this manuscript.

Funding This study was funded by the Hebei Province Medical Science Special Major Projects Research Fund.

Compliance with ethical standards

The CNFS was approved by the Institutional Review Board of the 3rd Hospital of Hebei Medical University. Written informed consent was obtained from each participant before data collection.

Conflict of interest The authors declare that they have no competing interests.

References

1. Riggs BL, Melton LJ 3rd (1986) Involutional osteoporosis. N Engl J Med 314:1676–1686
2. Pinheiro MDM, Camargos BM, Borba VZC, Lazaretticastro M (2009) FRAX TM: building an idea to Brazil. Arq Bras Endocrinol Metab 53:783–790
3. Pinheiro MM, Eis SR (2010) Epidemiology of osteoporotic fractures in Brazil: what we have and what we need. Arq Bras Endocrinol Metab 54:164–170
4. Chen W, Lv H, Liu S, Liu B, Zhu Y, Chen X, Yang G, Liu L, Zhang T, Wang H, Yin B, Guo J, Zhang X, Li Y, Smith D, Hu P, Sun J, Zhang Y (2017) National incidence of traumatic fractures in China: a retrospective survey of 512 187 individuals. Lancet Glob Health 5:e807–e817
5. Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, Tosteson A (2007) Incidence and economic burden of osteoporosis-related fractures in the United States, 2005–2025. J Bone Miner Res Off J Am Soc Bone Miner Res 22:465–475
6. Statement NIH Consensus (2001) Osteoporosis prevention, diagnosis, and therapy. JAMA 285: 785–795
7. Adachi JD, Ioannidis G, Pickard L, Berger C, Prior JC, Joseph L, Hanley DA, Olszynski WP, Murray TM, Anastassiades T, Hopman W, Brown JP, Kirkland S, Joyce C, Papaioannou A, Poliquin S, Tenenhouse A, Papadimitropoulos EA (2003) The association between osteoporotic fractures and health-related quality of life as measured by the health utilities index in the Canadian multicentre osteoporosis study (CaMos). Osteoporos Int 14:895–904
8. Johnell O, Kanis J (2006) Epidemiology of osteoporotic fractures. Osteoporos Osteoporos Rheum Dis 16:1–13
9. Kanis JA, Johnell O, Oden A, Johansson H, Mccloskey E (2008) FRAX and the assessment of fracture probability in men and women from the UK. Osteoporos Int 19:385–397
10. Lesnyak O, Ershova O, Belova K, Gladkova E, Sinitsina O, Ganert O, Romanova M, Khodirev V, Johansson H, McCloskey E, Kanis JA (2012) Epidemiology of fracture in the Russian Federation and the development of a FRAX model. Arch Osteoporos 7:67–73
11. Ross PD, Genant HK, Davis JW, Miller PD, Wasnich RD (1993) Predicting vertebral fracture incidence from prevalent fractures and bone density among non-black, osteoporotic women. Osteoporos Int 3:120–126
12. Ahn SK, Kam S, Chun BY (2014) Incidence of and factors for self-reported fragility fractures among middle-aged and elderly women in rural Korea: an 11-year follow-up study. J Prev Med Public Health 47:289–297
13. Huang C, Ross PD, Fujiwara S, Davis JW, Epstein RS, Kodama K, Wasnich RD (1996) Determinants of vertebral fracture prevalence among native Japanese women and women of japanese descent living in Hawaii. Bone 18:437–442
14. Abrahamsen B, Jørgensen NR, Schwarz P (2015) Epidemiology of forearm fractures in adults in Denmark: national age- and gender-specific incidence rates, ratio of forearm to hip fractures, and extent of surgical fracture repair in inpatients and outpatients. Osteoporos Int 26:67–76
15. Diamantopoulos AP, Rohde G, Johnsrud I, Skoie IM, Hochberg M, Haugeberg G (2012) The epidemiology of low- and high-energy distal radius fracture in middle-aged and elderly men and women in southern Norway. PLoS One 7:e43367
16. Tai SY, Wu IC, Wu DC, Su HJ, Huang JL, Tsai HJ, Lu CY, Lee JM, Wu MT (2010) Cigarette smoking and alcohol drinking and esophageal cancer risk in Taiwanese women. World J Gastroenterol 16: 1518–1521
17. Hughes A, Sathe N, Spagnola K (2008) State estimates of substance use from the 2005-2006 National Surveys on Drug Use and Health. Department of Health and Human Services, Substance Abuse and Mental Health Services Administration, Office of Applied Studies, 2008. [Available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.164.510&rep=rep1&type=pdf]
18. Johnell O, Kanis JA (2006) An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int 17:1726–1733
19. Brennan SL, Holloway KL, Williams LJ, Kotowicz MA, Bucki-Smith G, Moloney DJ, Dobbins AG, Timney EN, Pasco JA (2015) The social gradient of fractures at any skeletal site in men and women: data from the Geelong osteoporosis study fracture grid. Osteoporos Int 26:1351–1359
20. Wright NC, Saag KG, Curtis JR, Smith WK, Kilgore ML, Morrisey MA, Yun H, Zhang J, Delzell ES (2012) Recent trends in hip fracture rates by race/ethnicity among older US adults. J Bone Miner Res 27:2325–2332
21. Curtis EM, van der Velde R, Moon RJ, van den Bergh JPW, Geusens P, de Vries F, van Staa TP, Cooper C, Harvey NC (2016) Epidemiology of fractures in the United Kingdom 1988-2012: variation with age, sex, geography, ethnicity and socioeconomic status. Bone 87:19–26
22. Amin S, Achenbach SJ, Atkinson EJ, Khosla S, Melton LJ 3rd. (2014) Trends in fracture incidence: a population-based study over 20 years. J Bone Miner Res 29:581–589. https://doi.org/10.1002/jbmr.2072
23. Dettoni F, Peveraro A, Dettoni A, Rossi R, Castoldi F, Zareh A, Amberti F, Giai Via A, Bonasia D (2012) Erratum to: epidemiology of hip fractures in northwestern Italy: a multicentric regional study on incidence of hip fractures and their outcome at 3-year follow-up. Musculoskelet Surg 96:47–47
24. Høiberg MP, Gram J, Hermann P, Brixen K, Haugeberg G (2014) The incidence of hip fractures in Norway –accuracy of the national Norwegian patient registry. BMC Musculoskelet Dis 15:372
25. Icks A et al (2013) Incidence of hip fractures in Germany, 1995-2010. Arch Osteoporos 8:1–7
26. Hagino H (2007) Features of limb fractures: a review of epidemiology from a Japanese perspective. J Bone Miner Metab 25:261–265
27. Hagino H, Katagiri H, Okano T, Yamamoto K, Teshima R (2005) Increasing incidence of hip fracture in Tottori prefecture, Japan: trend from 1986 to 2001. Osteoporos Int 16:1963–1968
28. Yoon BH, Lee YK, Kim SC, Kim SH, Ha YC, Koo KH (2013) Epidemiology of proximal femoral fractures in South Korea. Arch Osteoporos 8:157
29. Sang-Rim K et al (2010) Incidence of hip fractures in Jeju Island, South Korea: a prospective study (2002-2006). Clin Orthop Surg 2: 64–68
30. Kanis JA, Johnell O, Oden A, Johansson H, de Laet C, Eisman JA, Fujiwara S, Kroger H, McCloskey EV, Mellstrom D, Melton LJ, Pols H, Reeve J, Silman A, Tenenhouse A (2005) Smoking and fracture risk: a meta-analysis. Osteoporos Int 16:155–162
31. Lutfy K, Aimiuwu O, Mangubat M, Shin CS, Nerio N, Gomez R, Liu Y, Friedman TC (2012) Nicotine stimulates secretion of corticosterone via both CRH and AVP receptors. J Neurochem 120: 1108–1116
32. Rasmussen DD (1998) Effects of chronic nicotine treatment and withdrawal on hypothalamic proopiomelanocortin gene expression and neuroendocrine regulation. Psychoneuroendocrinology 23: 245–259
33. Scholes S, Panesar S, Shelton NJ, Francis RM, Mirza S, Mindell JS, Donaldson LJ (2014) Epidemiology of lifetime fracture prevalence in England: a population study of adults aged 55 years and over. Age Ageing 43:234–240. https://doi.org/10.1093/ageing/aft167
34. Kanis JA, Johansson H, Johnell O, Oden A, de Laet C, Eisman JA, Pols H, Tenenhouse A (2005) Alcohol intake as a risk factor for fracture. Osteoporos Int 16:737–742

35. Stone KL, Ancoli-Israel S, Blackwell T, Ensrud KE, Cauley JA, Redline S, Hillier TA, Schneider J, Claman D, Cummings SR (2008) Actigraphy-measured sleep characteristics and risk of falls in older women. Arch Intern Med 168:1768–1775
36. Holmberg AH, Johnell O, Nilsson PM, Nilsson J, Berglund G, Åkesson K (2006) Risk factors for fragility fracture in middle age. A prospective population-based study of 33,000 men and women. Osteoporos Int 17:1065–1077
37. Kanis JA, Johnell O, de Laet C, Johansson H, Oden A, Delmas P, Eisman J, Fujiwara S, Garnero P, Kroger H, McCloskey EV, Mellstrom D, Melton LJ, Pols H, Reeve J, Silman A, Tenenhouse A (2004) A meta-analysis of previous fracture and subsequent fracture risk. Bone 35:375–382. https://doi.org/10.1016/j.bone.2004.03.024
38. Klotzbuecher CM, Ross PD, Landsman PB, Berger M (2000) Patients with prior fractures have an increased risk of future fractures: a summary of the literature and statistical synthesis. J Bone Miner Res 15:721–739
39. Wilsgaard T, Emaus N, Ahmed LA, Grimnes G, Joakimsen RM, Omsland TK, Berntsen GR (2009) Lifestyle impact on lifetime bone loss in women and men: the TromsÃ¸ study. Am J Epidemiol 169:877–886
40. Lu X, Siu KC, Fu SN, Hui-Chan CW, Tsang WW (2016) Effects of Tai chi training on postural control and cognitive performance while dual tasking - a randomized clinical trial. J Complement Integr Med 13:181–187

Affiliations

Guobin Liu[1,2,3] • Yansen Li[1,2] • Yanbin Zhu[1,2] • Wei Chen[1,2] • Xin Xing[2] • Jiashen Shao[1,2] • Song Liu[1,2] • Hongzhi Lv[2] • Chenni Ji[1,2] • Xiaolin Zhang[4] • Yingze Zhang[1,2,5]

[1] Department of Orthopaedic Surgery, The Third Hospital of Hebei Medical University, NO.139 Ziqiang Road, Shijiazhuang 050051, Hebei, People's Republic of China

[2] Key laboratory of biomechanics of Hebei Province, Shijiazhuang 050051, Hebei, People's Republic of China

[3] Department of Orthopaedic Surgery, The First Hospital of Hebei Medical University, Shijiazhuang 050000, Hebei, People's Republic of China

[4] Department of Statistics and Epidemiology, Hebei Medical University, Shijiazhuang 050000, Hebei, People's Republic of China

[5] Chinese Academy of Engineering, Beijing 100088, People's Republic of China