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Original Article

Relationship between the FRAX® score and falls in community-dwelling middle-aged and elderly people

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Abstract

Objectives: Falls is a risk factor for fracture. The FRAX® predicts fractures. Whether the FRAX® is associated with fall in both gender is inconclusive. The aim of our study is to evaluate the association between FRAX scores and falls.
Methods: The cross-sectional study set from 2009 to 2010 included 1200 community-dwelling people who were systematically sampled in central Taiwan. The 1200 participants (men: 524; women: 676; ≥40 years old) completed questionnaires about socioeconomic status; lifestyle; medical and fall history were completed. FRAX scores with and without bone mineral density (BMD) were calculated by using the Taiwan calculator.
Results: A total of 19.8% participants fell down. Binary regression models showed that diabetes mellitus history (OR: 1.61; 95% CI: 1.03−2.52), the FRAX without BMD in a continuous major score (OR: 1.06; 95% CI: 1.03−1.09), continuous hip score (OR: 1.11; 95% CI: 1.05−1.16), categorical major score ≥ 10% (OR: 1.81; 95% CI: 1.25−2.61), and categorical hip score ≥ 3% (OR: 1.80; 95% CI: 1.30−2.50) were independent risk factors for falls. FRAX with BMD in a continuous major score (OR: 1.04; 95% CI: 1.02−1.06), continuous hip score (OR: 1.06; 95% CI: 1.02−1.09), categorical major score ≥ 10% (OR: 1.52; 95% CI: 1.09−2.12), and categorical hip score ≥ 3% (OR: 1.53; 95% CI: 1.13−2.09) were also independent risk factors.
Conclusions: We concluded that FRAX® scores with and without BMD were unanimously correlated with falls in community-dwelling middle-aged and elderly males and females.

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Keywords: FRAX; Falls; Diabetes mellitus (DM); Community; Fracture

1. Introduction

Falls will cause osteoporotic fracture, subsequent severe immobility, hospitalization, or even death, and a huge economic burden for the elderly healthcare system [1]. Nearly 90% of fractures which mainly mean hip fracture are the result of falls by the elderly (≥65) [2–4]. On the contrary, history of vertebral fracture is also a risk factor of fall [5]. To prevent falls, many clinical checklists for detecting patients at a high-risk for falls are used [6]. However, not all of the risk factors for falling have been adequately addressed. Therefore, the fall prevention is still an unachieved goal [7]. The Garvan fracture risk calculator

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contained the item of fall has been successfully used in aged 50 and over Australian, but not for other ethnicity. The World Health Organization Fracture Risk Assessment Tool (FRAX®) is country-specific and clinically useful for detecting people over 40 year-old at a high risk of osteoporotic fracture [8]. The FRAX consists of 12 separate items including age, sex, weight, height, previous fracture, parental fracture history, glucocorticoids, rheumatoid arthritis, current smoking, alcohol 3 or more unit, secondary osteoporosis and femoral neck bone mineral density (BMD) [8], but the patient's history of falling is not one of them. Meanwhile, the FRAX items are similar to the clinical risk factors of falls [7,8]. The risk factors of osteoporosis and falls are also compatible to some degree, for example, old age, low exercise level, and limited mobility [9]. However, only limited study with inconsistent findings had been reported [10–12]. Researchers suggest that FRAX would be associated with falls in male Caucasian [10]. However, it was also debated that FRAX could not be a surrogate of falls [11] and should include the patient's history of falls in the algorithm [12]. Therefore, whether the FRAX should include falls is interesting but still being debated, especially without sufficient data to clarify the association between FRAX and falls in Asian and both gender. We hypothesized that the FRAX score was associated with falls without including the history of falls variable. Therefore, we examined the interrelationships between FRAX scores with and without BMD and the risk of falls in community-dwelling middle-aged (≥40 years) and elderly males and females.

2. Materials and methods

2.1. Study population

A systematically stratified method was used to sample the study participants [13]. Two Yunlin County townships (Douliou and Kukeng) were randomly selected in the first sampling step, and 1200 ambulatory Taiwanese residents (524 men; 676 women) ≥ 40 years old were enrolled at National Cheng Kung University Hospital's Douliou Branch from March 2009 through February 2010. The mean age and gender distribution were not significantly different from those of non-responders. This study was approved by the Institutional Review Board of National Cheng Kung University Hospital (IRB number: ER-98-084). The study methods were carried out in accordance with the approved guidelines. Signed informed consents were collected before the study began.

2.2. Data collection

2.2.1. Measurements and questionnaires

The participants' body height and body weight were measured after they had fasted overnight, and their body mass index (BMI) (kg/m^2) was calculated. Participants completed a structural questionnaire [13–16] that asked about lifestyle habits (e.g., exercise, smoking, and alcohol consumption), whether they lived alone or with someone else (roommate, family, etc.), socioeconomic status, past medical conditions, drug history, fall history, fracture history, and their parents' histories of hip fracture. Moderate exercise was defined as 50 min of exercise more than 3 times per week. Socioeconomic status was calculated according to a modified Hollingshead's index of social position and was categorized as low (levels 1–3) and high (levels 4 and 5). Habitual smoking and alcohol drinking were defined as stipulated by the FRAX [16]. Diabetes mellitus (DM) was defined as type II DM. Physicians diagnosed DM and hypertension (HTN) from the history taken using the questionnaires or determining whether the participants took oral antidiabetic drugs or antihypertensive drugs [13–16]. Arrhythmia, old cardiovascular accidents, osteoarthritis, rheumatoid arthritis, and secondary osteoporosis were also defined using history taking [13–17]. The amount of steroid intake was defined according to FRAX definitions [17]. Psychiatric drug use was defined if, on the structural questionnaires, the participants said that they were taking hypnotics or mood-disorder drugs [13–16]. History of fall within the previous year was defined [13] as unpredictably tilting downward when standing up, sitting, or walking, and then unintentionally contacting the floor with the upper or lower body when changing position. BMD was measured at the bilateral hip region using dual energy X-ray absorptiometry (DXA, Prodigy; GE Healthcare Life Sciences, Taipei, Taiwan). The lowest measured BMD of the bilateral femoral neck was used for the FRAX calculation. FRAX scores with and without BMD, including major osteoporotic and hip fractures, were calculated using the Taiwan calculator [17]. The cut-off value of FRAX (major) with or without BMD was set at 10% [18,19] and FRAX (hip) with or without BMD was 3% [20–23].

2.2.2. Data analyses and statistical methods

SPSSWIN 17.0 (SPSS, Inc., Chicago, IL, USA) was used for all statistical analyses. Continuous variables (age, BMI, and FRAX scores with and without BMD) are expressed as mean and standard deviation (SD), and categorical variables (socioeconomic status, living alone or with others, current smoking and drinking, exercise level, and histories of HTN, DM, arrhythmia, old cerebrovascular accident (CVA), osteoarthritis (OA), and psychiatric drug use) are all expressed as the number of cases and percentage. Participants who had fallen were assigned to the Faller^{Pos} group; those who had not were assigned to the Faller^{Neg} group. Between these groups, comparisons of categorical variables were analyzed using χ^2 tests, and continuous variables using independent *t* tests. Using the logistic regression models, the twelve separate items of the FRAX algorithm, with or without BMD, were used as independent variables to evaluate the risk factors associated with falls. Moreover, the integrated FRAX scores with and without BMD, and major osteoporotic or hip fractures, were used as independent variables in 8 binary logistic models. Participants were dichotomized for further analysis as having a FRAX score of major osteoporotic fracture ≥10% or hip fracture ≥3%. Because of the collinearity with the twelve items in the FRAX algorithm, age, gender, and BMI were not analyzed as independent variables in regression models. Except for the major items of the FRAX, the independent variables of living

alone or with someone, socioeconomic status, exercise level, and a history of DM, HTN, arrhythmia, old CVA, OA, and psychiatric drug use were also analyzed in binary logistic regression models. Significance was set at $p < 0.05$.

3. Results

Two hundred thirty-eight (19.8%) participants had 1 episode of falls at least in the year before the study began. Seventy-eight (6.5%) participants (male/female: 33/45) met more than 2 episodes of falls in the year before this study began. The average FRAX scores with and without BMD were 7.36% and 5.88% in ten-year major osteoporotic fracture probability, and 2.79% and 1.89% in hip fracture probability, respectively (Table 1). Faller^{Pos} group members were older, had higher percentages of DM histories, and higher FRAX (major or hip) scores with or without BMD than did Faller^{Neg} group members.

Using the 12 separate items of the FRAX algorithm along with the conventional risk factors as independent variables, we found that only age (odds ratio [OR]: 1.03; 95% confidence interval [CI]: 1.02–1.05) was independent risk factors for falls (Table 2).

To determine the independent interrelationships between FRAX scores, risk factors and falls, a series of eight binary logistic regression models were analyzed. A history of DM was an independent risk factor for falls in models II (OR: 1.59; CI 95%: 1.02–2.49), III (OR: 1.57; CI 95%: 1.00–2.45), and IV (OR: 1.61; CI 95%: 1.03–2.52) (Table 3). The continuous FRAX major osteoporotic score without BMD (OR: 1.06; 95% CI: 1.03–1.09), the continuous FRAX hip score without BMD (OR: 1.11; 95% CI: 1.05–1.16), the categorical FRAX major osteoporotic score without BMD ≥ 10% (OR: 1.81; 95% CI: 1.25–2.61), and the categorical FRAX hip score without BMD ≥ 3% (OR: 1.80; 95% CI: 1.30–2.50) were independent risk factors for falls. A history of DM in models V (OR: 1.58;

Table 1
Basic characteristics of patients.

Variables	Faller^{Pos}	Faller^{Neg}	Total
Number of cases	238 (19.8)	962 (80.2)	1200 (100)
Age (years)	62.96 (11.4)[b]	58.77 (11.2)	59.60 (11.4)
Men	98 (41.2)	426 (44.3)	524 (43.7)
Body mass index (kg/m^2)	24.52 (3.66)	24.65 (3.54)	24.63 (3.56)
Socioeconomic status (Hollingshead's index ≥ 4)	168 (70.6)	645 (67.0)	713 (59.4)
Living alone	18 (7.6)	58 (6.0)	76 (6.3)
Current smoker	21 (8.8)	100 (10.4)	121 (10.1)
Current alcohol drinking	12 (5.0)	77 (8.0)	89 (10.1)
Moderate exercise habit	6 (27.3)	287 (29.8)	352 (29.3)
Fracture history	25 (10.5)	74 (7.7)	99 (8.3)
Diabetes mellitus history	32 (13.4)[a]	82 (8.5)	114 (9.5)
Hypertension history	63 (26.5)	234 (24.3)	297 (24.8)
Arrhythmia history	13 (5.5)	40 (4.2)	53 (4.4)
Old CVA history	3 (1.3)	10 (1.0)	13 (1.1)
Osteoarthritis history	15 (6.3)	41 (4.3)	56 (4.7)
Secondary osteoporosis	0 (0)	0 (0)	0 (0)
Rheumatoid arthritis history	2 (0.8)	11 (1.1)	13 (1.1)
Psychiatric drug use	17 (7.1)	48 (5.0)	65 (5.4)
Steroid intake history	3 (1.3)	13 (1.4)	16 (1.3)
Parental fractured hip	14 (5.9)	68 (7.1)	82 (6.8)
Femoral neck BMD (g/m^2)	0.80 (0.15)	0.81 (0.13)	0.81 (0.14)
FRAX without BMD scores	–	–	
Major, continuous	7.10 (5.18)[b]	5.58 (4.57)	5.88 (4.74)
Major ≥ 10%	57 (23.9)[b]	137 (14.2)	294 (16.2)
Hip, continuous	2.60 (3.07)[b]	1.72 (2.54)	1.89 (2.68)
Hip ≥ 3%	77 (32.4)[b]	198 (20.6)	275 (22.9)
FRAX with BMD scores	–	–	
Major, continuous	8.82 (7.47)[b]	7.00 (5.80)	7.36 (6.21)
Major ≥ 10%	70 (29.4)[b]	200 (20.8)	270 (22.5)
Hip, continuous	3.70 (5.34)[b]	2.57 (3.72)	2.79 (4.12)
Hip ≥ 3%	89 (37.4)[b]	265 (27.5)	354 (29.5)

Faller^{Pos}: patients who had fallen; Faller^{Neg}: patients who not had fallen; CVA: cerebrovascular accident; FRAX: Fracture Risk Assessment Tool; BMD: bone mineral density.
Comparisons between Faller^{Pos} and Faller^{Neg} groups: Continuous data: mean (standard deviation), independent *t* test; Categorical data: n (%), χ^2 test.
[a] $p < 0.05$,
[b] $p < 0.01$.

Table 2
Logistic regression models of associated factors including the separate items of FRAX for falls in all patients (n = 1200).

Variables	Model A (without BMD)	Model B (with BMD)
Age (years)	1.03 (1.02–1.05)[a]	1.03 (1.02–1.05)[a]
Gender (Men = 1)	0.80 (0.58–1.11)	0.79 (0.57–1.10)
Body mass index (kg/m^2)	0.99 (0.95–1.04)	0.99 (0.95–1.03)
Current smoking habits (Yes = 1, No = 0)	1.08 (0.63–1.85)	1.08 (0.63–1.85)
Alcoholic habits (Yes = 1, No = 0)	0.71 (0.38–1.36)	0.71 (0.37–1.36)
Living alone (alone = 1, lives with others = 0)	0.95 (0.53–1.68)	0.95 (0.53–1.69)
Socioeconomic status (Hollingshead's index ≥ 4 = 1, <4 = 0)	1.03 (0.74–1.43)	1.03 (0.74–1.44)
Moderate exercise habits (Yes = 1, No = 0)	0.94 (0.67–1.30)	0.93 (0.67–1.30)
Fracture history (Yes = 1, No = 0)	1.39 (0.85–2.27)	1.40 (0.86–2.28)
Parental fracture history (Yes = 1, No = 0)	0.90 (0.49–1.64)	0.90 (0.49–1.64)
Rheumatoid arthritis history (Yes = 1, No = 0)	0.72 (0.15–3.40)	0.72 (0.15–3.38)
Steroid intake history (Yes = 1, No = 0)	1.05 (0.29–3.87)	1.06 (0.29–3.92)
Diabetes mellitus history (Yes = 1, No = 0)	1.44 (0.91–2.27)	1.43 (0.91–2.26)
Hypertension history (Yes = 1, No = 0)	0.87 (0.61–1.25)	0.87 (0.61–1.25)
Arrhythmia history (Yes = 1, No = 0)	1.29 (0.66–2.52)	1.30 (0.67–2.54)
Old CVA history (Yes = 1, No = 0)	0.98 (0.26–3.74)	0.99 (0.26–3.78)
Osteoarthritis history (Yes = 1, No = 0)	1.19 (0.63–2.25)	1.19 (0.63–2.25)
Psychiatric drug usage (Yes = 1, No = 0)	1.41 (0.78–2.56)	1.40 (0.77–2.55)
Lowest BMD from bilateral neck BMD		1.21 (0.40–3.67)

All values are odds ratio (95% confidence interval).
FRAX: Fracture Risk Assessment Tool; BMD: bone mineral density; CVA: cerebrovascular accident.
[a] $p < 0.01$.

Table 3
Logistic regression models of associated factors including FRAX without BMD for falls in all patients (n = 1200).

Variables	Model I	Model II	Model III	Model IV
Living alone (alone = 1, lives with others = 0)	0.98 (0.55−1.75)	1.06 (0.60−1.86)	0.98 (0.55−1.74)	1.06 (0.61−1.87)
Socioeconomic status (Hollingshead's index ≥4 = 1, <4 = 0)	1.05 (0.76−1.45)	1.06 (0.77−1.46)	1.07 (0.78−1.47)	1.08 (0.78−1.49)
Moderate exercise habit (Yes = 1, No = 0)	0.92 (0.66−1.27)	0.92 (0.66−1.27)	0.92 (0.66−1.28)	0.92 (0.67−1.28)
Diabetes mellitus history (Yes = 1, No = 0)	1.54 (0.98−2.41)	1.59 (1.02−2.49)[a]	1.57 (1.00−2.45)[a]	1.61 (1.03−2.52)[a]
Hypertension history (Yes = 1, No = 0)	0.96 (0.68−1.34)	1.00 (0.71−1.40)	0.96 (0.69−1.35)	0.96 (0.69−1.35)
Arrhythmia history (Yes = 1, No = 0)	1.30 (0.67−2.52)	1.23 (0.63−2.38)	1.30 (0.67−2.53)	1.27 (0.65−2.46)
Old CVA history (Yes = 1, No = 0)	1.06 (0.28−4.04)	1.16 (0.31−4.39)	1.01 (0.27−3.85)	1.01 (0.27−3.83)
Osteoarthritis history	1.25 (0.67−2.34)	1.23 (0.65−2.32)	1.29 (0.69−2.43)	1.27 (0.68−2.39)
Psychiatric drug usage (Yes = 1, No = 0)	1.37 (0.76−2.48)	1.38 (0.77−2.49)	1.40 (0.77−2.52)	1.41 (0.78−2.55)
FRAX without BMD scores				
Major, continuous	1.06 (1.03−1.09)[b]			
Major ≥10% (Yes = 1, No = 0)		1.81 (1.25−2.61)[b]		
Hip, continuous			1.11 (1.05−1.16)[b]	
Hip ≥3% (Yes = 1, No = 0)				1.80 (1.30−2.50)[b]

All values are odds ratio (95% confidence interval).
FRAX: Fracture Risk Assessment Tool; BMD: bone mineral density. CVA: cerebrovascular accident.
[a] $p < 0.05$;
[b] $p < 0.01$.

CI 95%: 1.01−2.47), VI (OR: 1.60; CI 95%: 1.02−2.50), VII (OR: 1.62; CI 95%: 1.04−2.53) and VIII (OR: 1.60; CI 95%: 1.03−2.50) was also an independent risk factor for falls (Table 4). The continuous FRAX with BMD major osteoporotic score (OR: 1.04; 95% CI: 1.02−1.06), the continuous FRAX with BMD hip score (OR: 1.06; 95% CI: 1.02−1.09), the categorical FRAX with BMD major osteoporotic score ≥ 10% (OR: 1.52; 95% CI: 1.09−2.12), and the categorical FRAX with BMD hip score ≥ 3% (OR: 1.53; 95% CI: 1.13−2.09) were independent risk factors for falls.

4. Discussion

We found that the prevalence of falls was 19.8%, similar with the findings in Taiwan [15] and worldwide [24−28]. The mean FRAX major and hip scores of total patients ≥40 years old in our study were 7.36% (with BMD), 5.88% (without BMD) and 2.79% (with BMD), 1.89% (without BMD), respectively (Table 1). The FRAX without BMD (major and hip) scores in our study were not significantly different from findings in Australia, the USA, and Hong Kong, but significantly lower than those in studies from Germany and Canada [29−34]. The FRAX with BMD major score in our study was significantly lower than that in studies from the USA, Canada, and Hong Kong in groups of >50-year-old patients with a history of fracture [29−34]. Although our patients were younger than those in other studies, their FRAX with and without BMD scores (both major and hip in this study) were distributed comparably to those in Western and other Asian countries [29−34].

Table 4
Logistic regression models of associated factors including FRAX with BMD for falls in all patients (n = 1200).

Variables	Model V	Model VI	Model VII	Model VIII
Living alone (alone = 1, lives with others = 0)	1.06 (0.60−1.87)	1.15 (0.66−2.00)	1.09 (0.62−1.91)	1.11 (0.63−1.94)
Socioeconomic status (Hollingshead's index ≥4 = 1, <4 = 0)	1.06 (0.77−1.46)	1.08 (0.78−1.48)	1.08 (0.78−1.48)	1.09 (0.79−1.50)
Moderate exercise habit (Yes = 1, No = 0)	0.94 (0.67−1.30)	0.91 (0.66−1.27)	0.94 (0.68−1.30)	0.92 (0.66−1.27)
Diabetes mellitus history (Yes = 1, No = 0)	1.58 (1.01−2.47)[a]	1.60 (1.02−2.50)[a]	1.62 (1.04−2.53)[a]	1.60 (1.03−2.50)[a]
Hypertension history (Yes = 1, No = 0)	0.99 (0.71−1.38)	0.99 (0.71−1.39)	1.01 (0.72−1.40)	0.98 (0.70−1.38)
Arrhythmia history (Yes = 1, No = 0)	1.24 (0.64−2.40)	1.20 (0.62−2.33)	1.23 (0.64−2.39)	1.23 (0.63−2.38)
Old CVA history (Yes = 1, No = 0)	1.05 (0.28−3.97)	1.05 (0.28−3.96)	1.02 (0.27−3.87)	0.98 (0.26−3.71)
Osteoarthritis history	1.36 (0.73−2.53)	1.34 (0.72−2.51)	1.43 (0.77−2.66)	1.39 (0.74−2.59)
Psychiatric drug usage (Yes = 1, No = 0)	1.42 (0.79−2.55)	1.39 (0.77−2.51)	1.44 (0.80−2.58)	1.42 (0.79−2.56)
FRAX with BMD scores				
Major, continuous	1.04 (1.02−1.06)[b]			
Major ≥10% (Yes = 1, No = 0)		1.52 (1.09−2.12)[b]		
Hip, continuous			1.06 (1.02−1.09)[b]	
Hip ≥3% (Yes = 1, No = 0)				1.53 (1.13−2.09)[b]

All values are odds ratio (95% confidence interval).
CVA: cerebrovascular accident; FRAX: Fracture Risk Assessment Tool; BMD: bone mineral density.
[a] $p < 0.05$;
[b] $p < 0.01$.

The separate items of the FRAX algorithm revealed only the age was the independent risk factors for falls, which is consistent with other reports [5,26]. In contrast, in regression models with integrated FRAX scores, in addition to the FRAX score (including the combined effect of age), DM history was an independent risk factor for falls. The conventional risk factors for falls—living alone, less moderate exercise, and a history of arrhythmia, old CVAs, OA, and psychiatric drug use—showed a consistent but non-significant trend of higher ORs for falls. In general, it is plausible that the combined effects of the twelve FRAX variables are more powerful than the effect of an individual risk factor for falls.

Consistent with the hypothesis, our study demonstrated that the FRAX (major/hip) score was positively associated with fall. Although the odds ratios of continuous FRAX (major) and FRAX (hip) were 1.04–1.11 for fall, it was small but statistically significant with clinical importance, just like the age as an undoubtedly risk factor for fall with odds ratio of 1.1 only [27]. Furthermore, using the cut-off point of FRAX (major) and FRAX (hip) at 10% [18,19] and 3% [20–23], the odds ratio even higher as 1.52 to 1.81. Therefore, the association between FRAX score and fall is obviously demonstrated. To prevent osteoporotic fractures, how to accurately assess the risk of falling is important. When the FRAX was first constructed, the algorithm did not include the patient's history of falls because of the widely varied definitions and prevalence of falls in the original FRAX cohort data [8]. As more studies reported that the history of falls was an independent risk factor for fracture [2–4], experts argued about whether that history of falls should be integrated into the FRAX algorithm [8,12]. Although the twelve items of FRAX are partially consistent with the conventional risk factors of fall, the evidence-based relationships between FRAX scores and falls are limitedly discussed [11]. In the original FRAX cohort data, the definition of a fall in 2 of the original cohorts [8] was similar to the one we used in our study. In our serial regression models, the FRAX scores with and without BMD were independently associated with falls. Moreover, the cutoffs at 10% for FRAX major osteoporotic fractures and at 3% for FRAX hip fractures regardless of BMD were also independent risk factors for falls. That is, the FRAX scores can be used for clinical assessments of falls.

Consistent with another report [35], a history of DM was an independent risk factor for falls in our study. DM-related complications like neuropathy, retinopathy, orthostatic complaints, and hypoglycemia can explain a higher incidence of falls [36]. Moreover, DM is a risk factor not only for falls [34,37] but also for fracture [36,38]. The adjusted hazard ratio for fracture was 1.66 (95% CI: 1.60–1.72) for people with DM [39]. Because people with DM experience more adverse events and greater subsequent mortality after a fracture [39], determining their risk for falling is important to help protect them against falls.

This study has some limitations. First, it was designed to screen a population with an underestimated risk for falls; therefore, disabled people with a clearly high risk for falls were not recruited for this survey. Furthermore, because only ambulatory patients were enrolled, lower limb stability was not assessed in the regression models of falling. In addition, age [40], comorbid DM [41], comorbid OA [42], and a history of old CVA [43] were associated with lower-limb stability. Second, the FRAX scores for single and recurrent falls were not separately analyzed. Fall will cause fractures [2–4], and recurrent falls which is also an episode of fall will also cause fractures. That is, fracture probability may be underestimated by FRAX in individuals with a history of frequent falls [8]. In order to prevent fracture, it is more practical to find out that who is the high-risk group of faller rather than who is the multi-faller. Therefore, we focused on the interrelationship between FRAX and fall, instead of fall frequencies. Clinicians should recognize and include in their decision-making that patients with frequent falls are at a higher risk for fracture than is currently estimated by FRAX [8]. Moreover, the interrelationship between a history of fracture and falls is well-recognized [2–5,7] but our models do not discriminate the circularity in the associations. Finally, because the study setting was Taiwan, an Asian country, the data should be interpreted with caution by Westerners. According to the FRAX map [21,34], Taiwan has the highest incidence of osteoporotic hip fracture in Asia and is the 9th riskiest area in the world. The results of our study can be used as a reference for high-risk areas of osteoporotic fracture, such as the USA and northern Europe.

5. Conclusions

FRAX scores with and without BMD, either of major osteoporotic fracture or of hip fracture, were associated with falls in men and women aged 40 and over. The DM history was consistently associated with falls and it is worth being concerned about fall prevention and the FRAX algorithm. Although the FRAX tool does not include a history of a patient's falls, FRAX scores can be used to reflect the risk of falls and the subsequent risk of fracture in community-dwelling middle-aged and elderly people. Because this is a cross-sectional survey, whether the FRAX score can be used to predict the incidence of falls is uncertain and merits future longitudinal studies.

Disclosures

None.

Author contributions

L.C.O wrote the paper. C.H.W helped write and revise the paper. L.C.O and C.H.W had the idea for the study and were involved in all aspects. Z.J.S and L.C.O recruited the study participants. Y.F.C and C.S.C helped with data interpretation and made statistical suggestions. Z.J.S, C.H.W, T.H.C, and R.M.L coordinated the study affairs and budget. All authors reviewed and approved the final paper.

Conflict of interest statement

All authors declared no conflicts of interest.

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