ORIGINAL ARTICLE

Relationship between risk of osteoporotic fractures and muscle strength in community dwelling adults

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Abstract:

Identified osteoporotic fracture risk is crucial as increase prevalence of aging population with low bone density. Frailty and falls commonly in adults with osteopenia than osteoporosis. This study aimed to examine the relationship between grip strength, biceps and quadriceps muscle strength, and 10-year probability of risk of osteoporotic fracture (FRAX). A cross-sectional study conducted among hundred community dwelling adults aged ≥40 years. Clinical risk factors screened by health screening questionnaire included demographic data, FRAX risk factors and other health-related information. Dynamometer used to measure grip strength, spring scale matric for bicep and quadriceps strength, Singapore model of FRAX Tool utilized to determine risk of hip and non-hip fracture. The mean age of participants was 58±8.7 years, almost all participants were at low risk of non-hip and hip fracture. The 10-year risk of hip and non-hip fracture had negative significant (all $p < 0.01$) correlation with hand grip strength (r = -0.22), bicep strength (r = -0.3- -0.38) and quadriceps strength (r = -0.2 & -0.34). Grip strength, biceps and quadriceps muscle strength may along assess with risk factors in FRAX Tool, as a health screening in identify who are at high risk of osteoporotic fracture in community dwelling adults.

Keywords: adult, bicep strength, knee strength and hand grip strength, risk of osteoporotic fracture

1. INTRODUCTION

Osteoporosis is characterized by low bone mass and deterioration of bone tissue leading to bone fragility and subsequently fracture [1]. It is a silent progressive disease and becomes clinically evident when there is a fracture [2]. Among the well documented sites of fractures are the spine, hips and arms. Fractures of the spine, vertebrae and hips are associated with long term morbidity such as chronic pain, deformity and disability, morbidities namely, depression, self isolation, low self esteem and loss of independence following fracture [2]. Rising yearly incidence of osteoporosis will have a significant impact on the healthcare financing system of the country [2].

Aging result in physical and biological changes in the structure and function of muscle. For example, decreases of the total muscle cross-sectional area by about 40% between the ages of 20 and 40 years [3], declined in the number of motor unit number and size of muscle fibers [3], muscle mass with loss of fast motor units and type II fibres. Also, loss of muscle strength and power leading to decreasing coordination and speed of muscle contraction [4], subsequently deteriorate in physical function [5].

An accelerated loss of muscle mass and strength occurs at an earlier age in women compared to men, around the time of menopause [6]. In study among older men examined the association between muscle strength, mass, and quality and functional limitation and physical disability and found muscle strength is the most useful indicator of aging population [7]The mechanisms leading to greater losses of muscle mass with aging in men and women are postulated to be related to hormonal factors including growth hormone, insulin-like growth factor, and androgens [8].

Menopause in women is associated with a natural decline in estrogens, that increases visceral fat mass, decreases bone mass density, muscle mass, and strength [6,9]. Early menopause is a significant risk factor for osteoporosis, fragility fracture and mortality [10]. In a cross-sectional study among 1050 physical inactive, entinean women aged 50–88 years reported that menopause before age 45 had lower bone mass density than women with later menopause, and about half of them had sustained a hip fracture. Epidemiological study established that a 1 SD decrease in BMD implies twice the risk of fracture in those with early menopause [11].

Declined in muscle strength in elderly people are most likely attributed no longer engage vigorously in daily activity [12]. Antigravity muscle at lower extremity such as quadriceps, hip extensors, ankle dorsiflexors, latissimus dorsi, and triceps [5] and most pronounced in the ankle dorsiflexors compared to knee, was linked to slower gait velocity and impaired response to postural perturbation [13]. Also, diminished lower extremity especially in ankle dorsi and

plantarflexion moments was correlated with loss of balance and falls in community-dwelling elderly persons [14]. Reduced strength of quadriceps and hamstring muscles often leading to inability to control postural and balance disturbance in daily activities [15] leading to increased risk of falls and fracture in elderly [16].

Whereas reduced upper extremity strength commonly the biceps and triceps strength may render the arms ineffective in arresting falls to the ground which further leads to wrist fracture [17] and increase the risk of hip fracture [18]. Also, the loss of muscle power (force and speed), leading to a greater impairment in functional performance which requires agility, such as standing and walking, and thus will increase susceptibility to falls and fractures [19].

Hand grip strength (HGS) has been identified as strong associative and predictor for BMD and osteoporotic fracture [20,21].Muscular weakness related to bone loss and osteoporotic-like changes in trabecular bone, alter the mechanical stress flow in bones, thereby causing under stressing specific skeletal sites and thus will interrupting the homeostatic conditions for normal bone mass maintenance [22]. This decline in skeletal muscle mass, or sarcopenia, is considered a major contributing factor to the loss of functional independence and frailty present in many older individuals [3]. The information of muscle strength to identifying risk of osteoporotic fracture in community setting is lacking. Therefore, this study aims to investigate the association of muscle strength and risk of osteoporosis especially in healthy community elderly 45 years above.

2. METHODOLOGY

A cross sectional study recruited hundred community dwelling adults through health screening program in Sekinchan, Subang Permai, Meru, and Sungai Udang, Selangor from September to December 2013. Subjects consist of Malay adult aged 40 years old and above. Participants excluded if they have any impairment affecting upper limb function such as neuromuscular disease, prior fragility fracture and musculoskeletal conditions. This study was approved by the university's ethical review board (600-FSK (PT.5/2). All subjects were informed regarding the purpose and procedure of the study and gave their written consent before entering the study.

Demographic data includes age, gender and race. In addition, for health history - subjects were asked if they have diagnosed with hypertension or diabetes while, for life style aspects – physical activity participation at least 3times per week with more than 30minutes per session, history of fall, year since menopause and vegetarian mode of eating were asked. Most importantly, subjects were screened for clinical risk factor based on FRAX, verbally.

2.1 Anthropometric data

Weight (kg) was measured using Omron weighing scale (HN 286, China) and standing height (cm) measured using a wall-mounted height measuring tape. Body mass index (BMI) then calculated and classified based on BMI classification for Asian [23].

2.2 Grip strength

HGS (in kg) was measured using J00105 Jamar dynamometer (Lafayette Instrument Company, United States of America) by trained physical therapist student. Hand positions was placed as described in manual guide for Jamar hydrolic hand dynamometer which, subjects adduct shoulder and neutrally rotate, elbow flexed to 90 degrees, while forearm and wrist in neutral position, in sitting position [24].

2.3 Biceps strength

The participants would be asked to perform an elbow flexing contraction with maximal ability against a resistance by using a spring (spring scale metric). It was measured on the side of the dominant hand of the participant in a sitting position. The spring will be adjusted so that the subject is sitting with their elbow flexed to 90 degrees. The participant was asked to contract maximally and hold for a period of 10 seconds. A series of three contractions with rest periods of 1 minute in between to ensure that maximal ability was achieved [25]. Maximal amount then recorded in kilogram (kg). The high reliability of muscle strength using a spring balance (ICC: > 0.75) [26].

2.4 Quadriceps strength

The subject was asked to perform knee extension contraction with maximal ability against a resistance by using a spring (spring scale metric). It was measured on the side of the dominant leg of the participant in a sitting position. The participant will be asked to contract with maximal ability just using their quadriceps. This contraction effort will be recorded for a period of 10 seconds. A series of three contractions with rest periods of 1 minute in between was performed to ensure maximal ability was obtained. For measurement of muscle strength a spring balance was the most reliable (ICC > 0.75 [26].

2.5 Risk of fracture assessment

The risk factors based on FRAX, keyed-in in FRAX Tool in order to obtain the ten year probability of fracture in percentage for major osteoporotic and hip fracture. Singapore model of FRAX Tool was utilized to determine 10-year probability of osteoporotic fracture. Subjects classified into high risk (>20%), medium risk (10%-20%) and low risk (<10%) for non-hip fracture and 3% cut off point for risk of hip fracture [27].

2.6 Statistical Analysis

Data were analyzed using Predictive Analysis Software (PASW) version 18.0. Subject's characteristics were described by means, standard deviations and percentages. Normality of variables and linearity of variables was ensured to fulfill assumptions of Pearson correlations. The 2-tailed Pearson correlations was employed to examine the relationship between 10-year probability of hip fracture and non hip fracture and hand grip strength, biceps and knee extensor muscle strength.

3. RESULT AND DISCUSSION

3.1 Prevalence of osteoporotic fracture risk

With refer to Table 1, the mean age of participants was 58±8.7 years, about 40% and 45 % participants are in the

category of overweight and obese respectively. The prevalence of low risk of non-hip fracture was 96% and all participants have low risk of hip fracture. One of the contributing factors to low risk of osteoporotic fracture may attribute to body weight. Several studies showed overweight and obese was correlated to bone mass [28,29] but conflict finding reported in study by Zhou et al. [30] who found that increased body weight and fat mass inversely correlated to bone mass. Another factor may be being a Malay itself has higher bone mass density compared to Chinese and Indian [31]. However, this study does not compare with other races and bone status predicted via probability of fracture using FRAX Tool, instead of bone mass density. Also, lifestyle of Malay has protective factor as obligation to their religion of Islam, forbid alcohol and requires prayer for five times a day, Prof. Ir. Dr. Fatimah Ibrahim stated that Muslims prayer involving repeated movements in standing, sitting, kneeling and bending involves isotonic and isometric contraction of the muscles hence, improve function, strength of the muscle [32] and spine flexibility [33]. For Malay women tends to be very homogenous, for example, they rarely use oral contraceptives or postmenopausal oestrogen replacement therapy. Despite, rural people plays an important role in yielding lower fracture risk as they are closely related to higher physical activity [34] such as walking due to limited transport or public transport. In addition, the natures of job of the subjects are mainly physically demanding compared to office worker which demands more on mental.

Table 1: Socio-demographic characteristics of participants.

Variables	N (%) Mean ±SD	Women, n=60 (60%) Mean ± SD	Men n=40(40%) Mean ± S.D.
Age, years	58.23±8.67	58.03	58.53
40-49	15(15%)		
50-59	44(44%)		
60-69	29(29%)		
70-79	11(11%)		
80-89	15(15%)		
BW, kg	66.49±13.14	64.66	69.23
Height, cm	153.77±21.28	152.38±21.21	155.21±21.58
BMI, kg/m^2	27.06±4.59	26.68±3.63	27.47±5.42
Normal (18.5-22.99)	14(14%)	11(11%)	3(3%)
Overweight (23.0-27.40)	41(41%)	21(21%)	20(20%)
Obese (≥27.5)	45(45%)	28(28%)	17(17%)
HGS, kg	19.36±7.63	17.69±6.11	21.87± 8.99
Biceps strength		11.4±4.68	13.31±3.75
Knee strength		15.25±5.81	16.93±4.83
NOM	45(75%)	45(75%)	-
AOM	49.62±4.90	49.62±4.90	-
YSM	10.31±7.86	10.31±7.86	-
History of falls		14(27.5%)	10(20.4%)
Risk of NHip #			
Low	96(96%)	56(56%)	40(40%)
Moderate	4(4%)	4(4%)	0
Risk of Hip #			
Low	100(100%)	60(60%)	40(40%)

BW=body weight, *Ht*:=height, *BMI*=body mass index, *HGS*= grip strength, *YSM*=years since menopause, A*OM*= age of menopause, *NOM*=number of menopausal women. *Nhip*=non hip

3.2 Relation between muscle strength and risk of fracture

Men scored greater grip strength compared to women (21.87kg ± 8.99, 17.69kg ±6.11, respectively). This present result was in good agreement with previous studies [20,35] that men has higher hand grip strength compared to women due to biomechanical advantages in men's musculosketal system and larger loss of trabeculae leading to decrease in bone strength in women [36].

3.3 Muscle strength and risk of fracture

Table 2 showed correlation between hand grip strength, biceps and quadriceps strength, history of falls, 10-year probability of hip fracture and non-hip fracture among adults.

Table 2*:* Pearson correlations between hand grip strength, 10-year probability of hip fracture and non-hip fracture among adult.

Variables	Hip #	Non hip #
Grip strength		-0.22**
Biceps strength	-0.30**	-0.38**
Knee strength	-0.28**	-0.34**

*$p < 0.05$, **$p < 0.01$

This study reinforces association between risk of osteoporotic fracture and muscle strength at lower and upper limb. Previous studies were consistently reported that frailty indicated by low grip strength, slow gait speed and chair raise predict hip fracture risk in older adults [37,38]. Established studies demonstrate remarkable relationship between hand grip strength and risk of fracture, which is consistent with majority previous study [20,38,39,40,41]. The previous studies on hand grip strength and risk of osteoporotic fracture has been conducted in Europe, Middle East and some Asian countries-Hong Kong and Korea, but not in Malaysia, which is a multi-racial country with Malay race as major population. Despite differences in sun exposure which influences Vitamin D uptake and economy stability which determines accessibility to healthcare, association of hand grip strength and risk of osteoporotic fracture in Europe and some Asian countries-Saudi Arabia and Korea, consistent with our present findings. Even though literatures discussed utilized bone mass density measurement whereas this study utilize fracture risk assessment calculation tool (FRAX Tool) without BMD yet, the degree of association achieved are about similar.

In regards of the association of hand grip strength with risk of fracture from this study combined with predictor ability of hand grip strength for risk of fractures [20,40], it suggested hand grip strength as a screening tool in addition to bone mass density for assessing risk of fracture. Mechanostat theory which proposes that, in order to retain strain in result of physiological loads, bone adapts to their strength [42]. Simply, muscle force works and bone strength and synchronically to withstand large physiological loads by muscle contraction. Strain on bone has beneficiary effect of stimulating bone remodeling however, it existed for strain of 1500 μ while, 15000 μ strain results in fracture [43]. This may help in explaining association between muscle strength in included upper and lower extremity muscle strength and risk of fracture.

3.4 Years since menopause and Risk of osteoporotic fracture

Years of menopause are crucial in determining total endogenous estrogen exposure, besides years of menstruation, pregnancy, regularity and duration of menstrual cycle and lactation [44]. Most of the studied in

relation of years since menopause and risk of osteoporotic fracture, only includes women or further specified into postmenopausal women. However, this study involves men and women. Of all women, 75% of them had mean 10 years of post-menopausal. Previous study was demonstrated that the significant relationship of menopause duration with risk of previous fragility fractures and revealed menopausal duration as dependent predictor for previous fragility fracture [40]. Our present finding showed year of menopaused significant correlated to risk of osteoporotic fracture (r = 0.64 & 0.62 for hip and non-hip fracture, respectively, both $p < 0.01$)(not in the data) which is consistent finding with previous study whereby, years since menopause correlates to fragility fractures among Saudi postmenopausal women [41], Korean women [40]. Conversely, contradictory evidence also presented for this variable whereby, duration of menopause not significantly associated with 15-year fragility fracture [21]. The conflicting finding is mainly attributed to methodology where Sirola et al. [21] utilized dual-energy X-ray absorptiometry to measure bone mass density of spine and hip recruitment of women in perimenopausal and post-menopausal women.

In summary, we found a negative correlation between muscle strength and osteoporotic fracture risk. We acknowledge that our study is cross sectional in nature instead of longitudinal design. It should also be noted that the sample size in this study is small and they are only Malay whereas Malaysia is a multiracial country. In conjunction to that, subjects should include Chinese and Indian too. Therefore, future longitudinal study to recruited larger sample will be helpful in clarifying the relationship of muscle strength and risk of osteoporotic fracture. Also, comparison with institutionalized population is necessary as this will allow in-depth comparison between high risk and low risk of osteoporotic fracture.

This study recommends that screening assessment should be held routinely in order to provide early awareness for prevention osteoporotic fracture. Screening assessment may initiate with FRAX Tool with physical assessments incorporating muscle strength at upper and lower limb. Once individual found to be in moderate risk, high accuracy assessment tool should be prescribed.

4. CONCLUSION

Our result showed a negative correlation between muscle function of biceps, quadriceps and hand grip strength and 10-year probability of osteoporotic fracture risk. In addition, we reaffirmed that good muscle strength may include as management strategy in order to prevent osteoporotic fracture among community dwelling adults.

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