RESEARCH ARTICLE

Relationship between muscle strength, balance and gait speed among knee osteoarthritis patients with sarcopenia and non-sarcopenia

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Abstract:

Sarcopenia and Osteoarthritis (OA) are degenerative musculoskeletal condition affects physical functioning in adults. This study aimed to compare the muscle strength, balance and gait speed (GS) between knee OA patients with sarcopenic and non-sarcopenic, and investigate the relationship of muscle strength, balance and GS among knee OA patients with sarcopenic and non-sarcopenic. A cross-sectional study recruited 57 knee OA participants aged 45-74 years (54 females, 3 males) from primary health care clinic. SARC-F questionnaire was used to screen sarcopenia status. Knee extensor strength (KES) and hand grip strength (HGS) were assessed by hand-held dynamometer. Balance and GS measured by tandem stand and four-meter walk test, respectively. The Mann-Whitney U test was used to compare the muscle strength and physical performances between knee OA patients with sarcopenic and non-sarcopenic. Spearman's correlation was used to evaluate the association between muscle strength and physical performance and anthropometric variables. There were significant ($p < 0.05$) lower of HGS, GS and balance in knee OA with sarcopenic group compared to non-sarcopenic group. Both balance (rs= 0.40, p <0.05) and left calf circumference (rs= 0.42, $p < 0.05$) was correlated with HGS in knee OA patients with sarcopenic group. Gait speed (rs= 0.36, $p < 0.05$) and right and left calf circumference (rs= 0.54-0.55, respectively, both $p < 0.05$) were correlated with HGS in knee OA patients. Muscle strength is age-associated and may affect balance among sarcopenic knee OA group. Thus, include muscle strength training and improve balance may prevent sarcopenia in patients with knee OA group.

Keywords: Knee OA, muscle strength, physical performance, sarcopenia

1. INTRODUCTION

Osteoarthritis (OA) is a chronic degenerative and progressive joint disease that may lead to disability and pain [1]. It is also one of the major contributors to disability in older people and related with increased mortality and decreased quality of life [2]. Cartilage decay is thought of the characteristic of OA. There are significant changes in chondrocytes and extracellular matrix with age [3]. For these reasons, the function of cartilage and its ability to deal with mechanical or environmental stress factors are expected to lead to OA development [3]. The most frequently affected joint is knee joint as a result of wear and tear or progressive loss of articular cartilage [4-5]. Quadriceps muscle weakness is reported to be present without knee pain in older adults with knee OA [2]. Estimated prevalence which 5-13% would affect 50-70 years old and 11-50% affect 80 years old and above [6].

Global Burden of Disease 2010 documented approximately 251 million people are diagnose with knee OA [5]. The prevalence of knee OA in the elderly population was approximated to be 10% to 20% in Malaysia, while about 19% of American adults aged 45 and older diagnosed with knee OA [7]. Age is the most outstanding risk factor for knee OA commencing and developing. Intrinsic alteration with age will stiffen the collagen network at the joint and increased glycation and affect cartilage and joint function [3].

Age, body mass index and quadriceps strength factors were significantly related to sarcopenia [8]. Aging related to a progressive and pervasive loss of skeletal muscle mass and muscle strength which may be associated with sarcopenia [9]. Sarcopenia is a gradual loss of muscle mass and muscle power and muscle function in elderly which affect power and performance [9]. The stated condition is diagnosed as sarcopenia (European Working Group on Sarcopenia in Older People (EWGSOP). Primary or also known as age-related sarcopenia is the disease that refers to no other apparent cause other than aging. Secondary sarcopenia refer to activity-related sarcopenia, sarcopenia associated with illness and nutrition-related sarcopenia [9]. Sarcopenia can lead to impairment and decreased physical activity and muscular strength, such as lower limb and handgrip muscle strength, weak balance and slower GS [10-11]. Thus, it will reduce strength and muscle function [1, 12]. Impaired mobility and day-to-day work, increased risk of falling, decreased independence and shorter life expectancy are also the main cause of sarcopenia [13]. This study aimed to compare the muscle strength, balance, and gait speed between adults with sarcopenia knee OA and non-sarcopenic knee OA in respect of and to examine the relationship of muscle strength, balance and GS in both groups.

2. MATERIALS AND METHODS

A cross-sectional study, purposive sampling of 57 subjects were recruited at Klinik Kesihatan Seksyen 19, Shah Alam and Klinik Fisioterapi UiTM Puncak Alam. This study was approved by the Ethic Committee UiTM (600-TNCPI (5/1/6REC/727/19) and Ethic Committee Ministry of Health Malaysia (KKM/NIHSEC/P19-2085(10). This study involved adults (45-75 years) diagnosed with knee OA refer by the medical officer. Data were collected from December 2019 to June 2020.

Sample size calculation was based on algorithm described by Guenther [14]. Sample size of 46 is needed to be able to detect correlation coefficient of 0.4 with alpha of 0.05 and power of 80.0%. Subjects who met any of the following exclusion criteria were not enrolled: long bones and joints deformities such as gout and rheumatoid arthritis, injection of corticosteroid or hyaluronic acid agent within the past four weeks, post total knee replacement, amputation, any surgery of lower limb, diabetic with neuropathy, history of anterior cruciate ligament/meniscus tear, neurological deficits, cognitive dysfunction, severe comorbidities such as chronic obstructive airway diseases, obvious tremor symptoms, a severe visual impairment, chronic kidney disease that could interfere with physical performance and severe backaches.

All participants were fully informed of the nature and gained their consent. Social and demographic data included age, gender, race and status were obtained by means of face-to-face interviews with the participants.

2.1 Anthropometric data

Height was measured using a portable stadiometer (Seca model 213) to the nearest 0.1 cm while for body weight and Bioelectrical Impedance Analysis (BIA) was measured using a body composition monitor and scale (Omron model HBF-514).

2.2 SARC-F Questionnaire

The SARC-F determines the level of difficulty experienced for the 5 components of muscle strength, walking assistance, rising from a chair, climbing stairs and falling, with a score range of 0 to 2 points for each item on three levels. The total score range is from 0 to 10, with scores of 4 points and above as the criteria for sarcopenia. European working group on sarcopenia in older people (EWGSOP2) is recommended SARC-F for clinical practice and research [15].

2.3 Handgrip Strength (HGS)

Subjects were in a seating position with shoulder adducted, elbow flexed to 90 degrees, forearm and wrist in a neutral position. As the indicator needle reset to zero, the subject was guided to grip the handle as tightly as possible without jerking movement. The best performance of three assessments was recorded in kilograms (kg) on each hand, and the maximum value on either side was used for analysis. Studies used HGS to assess muscle strength in the elderly [16-18]. HGS was showed to be a reliable measurement tool for in older adults [19].

2.4 Knee Extensor Strength (KES)

The test was carried out by the participants in a sitting position with a 90-degree flexion in hip and knee against a backrest with their back [20-21]. Rigid belt at the anterior part of the shin right above the knee, and the handheld dynamometer (HHD) placed behind the hip. The participants performed one submaximal muscle contractions to get familiar with the test procedure. Participants were told to extend their knee by pressing toward the HHD. The best performance of three trials per leg was recorded. The maximum value of either side was used for analysis. The HHD has demonstrated moderate intra-rater reliability (ICC = 0.71) and good to excellent validity (ICC $\geqslant$ 0.75) for measures of isometric lower limb strength [21].

2.5 Tandem stance

The tester stood on at least one side of the participant, providing assistance on one arm if necessary, until the participant felt secure in tandem position, one foot forward and touching the opposite foot. The forward foot had been chosen by the participants themselves. Minimum assistance was given to avoid loss of equilibrium. The minimum support was not reported on the data collection form or factored into the score otherwise. Timing began as support was released and remained for 10 seconds or until the participants moved out of the proper position. Participants who did not feel stable to start timing were considered unable to attempt the test. Franchignoni et al. [22] reported excellent inter-rater (ICC=0.99) and test-retest reliability (ICC=0.90-0.91) of tandem stance with eyes open.

2.6 Gait Speed Test (GS) (4-Metre walk test)

Participants were asked to walk through a one-meter zone for acceleration, continue to walk for 4-meter area and walk for another one-meter for deceleration. Time was recorded once the subject step at the four-meter area and the timer was stopped after the four-meter zone. EWGSOP2 has developed an algorithm for GS measurement ($\leq$0.8 m/s) as the simplest and most reliable way to determine sarcopenia. Arthritis patient significantly associated with slower GS compared to non-arthritis patient [23].

2.7 Statistical Analysis

The continuous data was shown as mean ± standard deviation. Whereas categorical data were presented with the number and percentage. Mann-Whitney U test was used to determine the muscle strength, balance, and GS between knee OA patients with sarcopenic and non-sarcopenic, as the data were not normally distributed. Bivariate analysis was performed using Spearman's correlation coefficient to determine the relationship between muscle strength, balance and GS in knee OA patients with a sarcopenic and non-sarcopenic group. Statistical analysis was performed using the Social Sciences Statistical Package (SPSS) software (IBM SPSS, version 23, Armonk, NY, 2013) and a level of significance of 0.05 was used for all statistical analyses.

3. RESULTS AND DISCUSSION

3.1 Characteristic of the participants

Table 1 showed the sociodemographic and characteristics of participants. The prevalence of sarcopenia and non-sarcopenia was 43.9% (n=25) and 56.1% (n=32), respectively. The mean age of 57 participants included in this cross-sectional study was 61.32 ± 7.20 years that ranged from 47-75 years. Majority of the participants was at the age of 55-64 years with 49.1% and 75 years and above was the least number of participants with 1.8%. Female accounted for over three-quarter (94.7%) compared to male (5.3%). Most participants consisted of Malay (78.9%) whereas the remaining were Indian (17.5%) and Chinese (3.5%).

Table 1: Sociodemographic and characteristics of knee OA by sarcopenic status.

Variables	Sarcopenia n=25 (43.9%)		Non-sarcopenia n=32 (56.1%)	
	n(%)	**Mean ± SD**	**n(%)**	**Mean ± SD**
Age, years		62.48 ± 6.55		60.41 ± 7.65
45-54	2(8)		7(21.9)	
55-64	13(52)		15(46.9)	
≥65	10(40)		10(31.2)	
Gender				
Female	24(96)		30(93.8)	
Male	1(4)		2 (6.3)	
Race				
Malay	16(64)		29(90.6)	
Non Malay	9(36)		3(9.4)	
BMI, kg/m^2		29.85 ± 5.02		30.9 ±4.76
Total body fat, %		38.17±6.14		37.48±5.98
Total muscle mass, %		23.6 ±5.81		9.56 ± 7.34
KES, kg		6.72 ±2.04		7.67 ± 2.41
HGS, kg		18.48 ±5.53		22.63±7.03
Tandem Stand, sec		6.7 ±3.21		8.81 ± 2.19
GS, sec		6.45 ±2.43		5.20 ± 2.40

BMI=Body Mass Index, GS=Gait speed, **HGS**=Grip Strength, **KES**= Knee Extensor Strength

The Mann-Whitney U test showed no significant ($p > 0.05$) difference between groups in respect of bodyweight, height, BMI except for total muscle mass in sarcopenic knee OA participants which was 23.6 ± 5.82 kg and non-sarcopenic knee OA participants was 29.6 ± 7.34 kg (both $p < 0.001$).

Table 2 displayed the comparison result of physical performances between sarcopenic knee OA group and non-sarcopenic knee OA group. There was higher of mean KES in non-sarcopenic knee OA group 7.67 ± 2.41 kg compared to sarcopenic knee OA group 6.72 ± 2.04 kg ($p = 0.28$). The mean time taken to complete a 4-meter walk test in sarcopenic knee OA group was significantly higher 6.45 ± 2.43 sec compared to non-sarcopenic knee OA group which was 5.20 ± 2.40 sec ($p = 0.02$). Tandem stance in sarcopenia group had the worse mean time which was 6.72 ± 3.21 sec compared to non-sarcopenia group 8.81 ± 2.19 sec ($p = 0.01$). The mean HGS was significantly higher in non-sarcopenic knee OA group 22.63 ± 7.03 kg compared to sarcopenia knee OA group 18.48 ± 5.53 kg with mean difference of 4.15 kg.

Table 2: Comparison of physical performances between groups

Variables	Sarcopenia (n = 25)	Non-sarcopenia (n = 32)	*p*-value
	m ± SD	**m ± SD**	
Muscle strength			
Knee extensor (kg)	6.72± 2.04	7.67 ± 2.41	0.28
Grip strength (kg)	18.48 ± 5.53	22.63 ± 7.03	0.01*
Balance			
Tandem stance	6.72 ± 3.21	8.81 ± 2.19	0.01*
Gait speed			
4-metre walk test	6.45 ± 2.43	5.20 ± 2.40	0.02*

*$p < 0.05$

Table 3 showed the correlation between physical performances and characteristics (age, BMI, total body fat, total muscle mass and calf circumference) among sarcopenic knee OA group and non-sarcopenic knee OA group by using Spearman correlation coefficient. There was no significant correlation ($p > 0.05$) between knee extensor muscle strength, balance, and GS in sarcopenic knee OA group and non-sarcopenic knee OA group.

In sarcopenic knee OA group, there was significant (all $p < 0.05$) weak positive correlation between HGS, and balance (rs = 0.40), and left calf circumference (rs = 0.42), but weak negative correlation with age (rs= -0.41). However, there is no statistical significance ($p > 0.05$) correlation between KES, GS and balance.

In non-sarcopenic knee OA group, the HGS is weak negative correlation with GS (rs= -0.36, $p < 0.05$), moderate positive correlation with right calf circumference (rs= 0.54, $p = 0.001$) and left calf circumference (rs=0.55, $p = 0.001$). Where, the KES is significant moderate positive correlation between with right calf circumference (rs=0.51, $p = 0.003$) and left calf circumference (rs= 0.61, $p < 0.001$).

Table 3: Correlation of sarcopenic knee OA and non-sarcopenic knee OA with physical performances

Variables	KES	HGS	GS	Balance	Right CC	Left CC
Sarcopenia knee OA						
KES	1	0.32	-0.22	0.24	0.25	0.31
HGS	-	1	-0.30	0.40*	0.28	0.42*
GS	-	-	1	-0.26	0.06	-0.01
Balance	-	-	-	1	0.26	0.29
Non-sarcopenia knee OA						
KES	1	0.32	-0.17	0.13	0.51**	0.61**
HGS	-	1	-0.36*	0.05	0.54*	0.55**
GS	-	-	1	-0.03	-0.03	-0.10
Balance	-	-	-	1	-0.30	0.22

CC= calf circumference, GS=gait speed, HGS= hand grip strength, KES=knee extensor strength.
$*p < 0.05$, $**p < 0.001$

3.2 Comparison of muscle strength, balance and gait speed by sarcopenic status

Participants in the sarcopenic knee OA group had a slightly lower score in HGS compared to the non-sarcopenic OA group. This result agrees with previous studies where sarcopenic group HGS was lower than non-sarcopenic group [16,24]. However, knee OA criteria was not included in their studies. Decreased physical activities, increased impairment, and loss of independence are the result of a progressive reduce in muscle mass and ageing muscle strength [10]. Decreases in size and number of skeletal muscle fibers, mainly type 2 or fast-twitch muscle fibers occurred as a result of progressive physiological and morphological changes in the skeletal muscle [25]. The satellite cell that will be activated and initiate the process of skeletal muscle regeneration and repair in response to stress is reduced in size, and more specifically in the skeletal muscle fibers of type 2 in older adults [25].

The present study showed that GS in the sarcopenic knee OA group was significantly higher than in the non-sarcopenia knee OA group. This finding consistent with previous study where a strong association between sarcopenia and GS was found in a sample of 19, 705 older adults [26]. Declining GS in participants of the sarcopenic knee OA might be due to loss of muscle strength or knee pain and consequently lead to physical inactivity. They might be prone to certain diseases with time, such as cardiovascular disease. GS is interrelated among sarcopenic participants and ADL dependence and this proves the previous statement [26].

Balance shows statistically significant differences between both groups and sarcopenic knee group OA had the worse mean time compared to the non-sarcopenic group OA knee. This study agrees with previous study which stated Centre of Pressure (CoP) sway both mean speed and mediolateral range were significantly ($p < 0.05$) higher in severe sarcopenia compared with both non-sarcopenia and pre-sarcopenia groups [27]. Though their study was conducted in total of 196 women with sarcopenic and non-sarcopenic groups without diagnosed with knee OA.

3.3 Correlation between muscle strength, balance and gait speed by sarcopenic status and anthropometric variables

Present study shows a positive correlation in the knee OA group with sarcopenic between HGS and the static balance measured by a tandem stance and this result consistent with finding from previous study [28]. However, these results conflict with other study where there is no correlation between HGS and static balance in a sample of 110 older adult women [29]. This controversial findings might be due to the loss of proprioception experienced by knee OA patient, which may affect postural stability and risk of falling as knee OA requirements was not included in previous study [29].

In this present study, there is no correlation between KES, balance, and GS in sarcopenic knee OA and non-sarcopenic knee OA groups. This finding opposes in previous study of 679 sarcopenic participants in younger and older adults where GS has been associated with lower limb strength [18]. The controversial findings can be explained by the variety of measuring instruments used in the studies. The present study used a hand-held dynamometer (HHD) while the previous study used the Repeated Chair Stand (RCS) to measure lower limb muscle. On the other hand, the reliability and validity of both measuring devices were good [21, 30]. One of the factors that affected the findings could also be the number of participants recruited, as the present study has a smaller sample compared to the previous study. However, the author believes that measuring KES using HHD in participants of sarcopenic knee OA is more sensitive compared with RCS [31]. This is due to KES measurement focusing primarily on the muscle quadriceps and quadriceps strength is a primary determinant of both performance-based and self-reported physical function in knee OA subject [31].

This study had some limitations. First, this is a cross-sectional study that makes it less likely to observe changes in muscle mass, muscle strength, and physical performance with knee OA subject aging. Clearly, to further determine the relationship between muscle strength, balance, and GS among the sarcopenic knee OA group, more research is required, particularly longitudinal study. The study's cross-sectional nature limits the finding's causality as the sample size was not large enough and impaired the ability to distinguish differences between groups (sarcopenic vs. non-sarcopenic).

In the future study, the location of the study also needs to be contemplated. Bigger space is required to set up the test to make the participants more comfortable while performing the test.

4. CONCLUSION

Our result showed that muscle strength, balance and gait speed in sarcopenic knee OA group was worse compared to non-sarcopenic knee OA. A positive correlation was found between HGS and balance in sarcopenic knee OA group. This study will provide an extensive review to knee OA patients, physiotherapist and other health-care professionals involved in knee OA sarcopenia rehabilitation management.

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