Original Research

Association between Muscle Mass and Muscle Strength with Physical Performance in Elderly in Surabaya

Titin Kristiana[1], Novira Widajanti[1], Rwahita Satyawati[2]

[1] Department of Internal Medicine, Faculty of Medicine, Universitas Airlangga/ Dr. Soetomo General Hospital –Indonesia

[2] Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Airlangga/ Dr. Soetomo General Hospital –Indonesia

Corresponding Author:
Novira Widajanti, dr., Sp.PD, KGER, Department of Internal Medicine, Faculty of Medicine, Airlangga University/Dr. Soetomo General Hospital–Indonesia Mayjend Prof. Dr. Moestopo Str. No. 47, Surabaya, Jawa Timur, 60131, Indonesia
Phone: - / **Email**: novirawijanti@yahoo.com

ABSTRACT

Background: Sarcopenia is a decrease in muscle mass and strength that mostly happens in the elderly. Sarcopenia is a problem that is often found in the elderly who are at risk of disability, hospitalization and death. This data on muscle mass and strength with physical performance is expected to support the theory of sarcopenia and as a reference in promoting and preventing sarcopenia in elderly.

Aims: To analyze the association between muscle mass and strength (handgrip strength) with physical performance assessed using Short Physical Performance Battery (SPPB) in an elderly community.

Methods: This study was a cross-sectional observational analytic study involving 203 sample of elderly (age ≥60 years old). The subjects were categorized as the strong and weak muscle mass and muscle strength, also the high, moderate and low physical performance. We used Bioimpedance Analysis (BIA) and hand dynamometer to measure muscle mass and muscle strength (handgrip strength). SPPB was used to assess physical performance.The association between muscle mass and strength with physical performance was displayed in bivariate analysis with chi square.

Result: Of all 203 subjects, 57 were males and 146 were females. Chi square test showed association between muscle strength (handgrip strength) with physical performance (SPPB) (p=0.001), with a weak correlation (r=0.26) and no association between muscle mass and physical performance (SPPB) (p=0.517).

Conclusion: There is a positive association between muscle strength with physical performance, with a weak correlation and no association between muscle mass and physical performance in the elderly community in Surabaya.

Keywords: *Muscle mass, muscle strength, handgrip strength, physical performance, elderly*

Introduction

Sarcopenia is a decrease in muscle mass and strength that mostly happens in the elderly. Sarcopenia is a problem that is often found in the elderly who are at risk of disability, hospitalization, and death. The Asian Working Group for Sarcopenia (AWGS) in 2014 stated that the Asian population has the highest prevalence for low muscle mass, low strength, and low physical performance compared to non Asian, ranging from 4.1% to 11.5%[1] Limpawattana et al.(2015) in Thailand showed a low muscle mass prevalence in Asia 22.1% for males and 21.8% for females.[2] Physical performance is an important thing in physical function which impacts the mobility, independency, and quality of life in elderly. Sarcopenia decreases the physical performance and eventually leads to worse outcome.

Physical performance is affected by muscle mass and strength. Factors influencing muscle mass and strength are the following: age, sex, ethnicity, weight, Body Mass Index (BMI), cardiac disease, dyslipidemia, low protein and vitamin D intake, and low physical activity.[1]Other factor contributing to the decrease in muscle strength is the decrease of motor unit, causing muscle fiber atrophy.[3] The cross-sectional study by Kim et al., 2012 in Korea showed that muscle mass is not correlated with physical performance assessed using Short Physical Performance Battery (SPPB) in frail elderly.[4] However, cohort study by Hughles et al., 2001 in England showed after follow-up of 12 years there was a significant change in quadriceps muscle with loss in extension strength of the knee in elderly males. Furthermore, a cohort prospective study by Kim et al., 2016 in Korea showed that muscle strength (handgrip strength) is a better indicator than muscle mass to physical performance assessed with SPPB in elderly.[5] The cohort prospective study by Legrand et al., 2013 in Belgium showed an association between muscle strength (handgrip strength) with physical performance assessed using SPPB in elderly in a community.[6] The data of muscle mass and strength (handgrip strength) with physical performance assessed using SPPB in elderly in Indonesia is still lacking.

In elderly there is a faster decrease in muscle strength than muscle mass. If the decrease in fast-type muscle fibers greater than in slow-type muscle fibers, it will strongly affects the muscle strength. The mitochondria change happening in subcellular level causes a decrease in muscle function in the elderly.[3] The European Working Group on Sarcopenia in Older People (EWGSOP) in 2010 recommended several tests to assess physical performance: walking speed, 6-minutes walking test, stair-climbing test, timed-up-and-go test (TUG) and Short Physical Performance Battery (SPPB).[7,8] Short Physical Performance Battery consists of balance test also walking speed, strength and endurance assessment by assessing individual's ability to stand in side-by-side feet position, semi-tandem, and tandem position, the time to walk for 8 feet and time to stand from a chair and back to sitting for 5 times. Physical Performance Battery (SPPB) is an appropriate, easy, reliable, practically usable test and represents all other physical performance tests.[7] The muscle mass assessment is done using Bioimpedance Analysis (BIA), this device is easy to carry, cost-effective, with easy and fast preparation, non-invasive, radiation-free, and comfortable to be used to assess sarcopenia in community.[9]

Handgrip strength is assessed using hand dynamometer, which has a good and safe results, also with a reasonable price and easy to get and use.[10] This corresponds to the study to test a device's validity to measure muscle mass, strength and physical performance by Mijnarends et al., 2013 in the Netherlands, who stated that measurement of muscle mass using Bioimpedance Analysis (BIA) device, muscle strength (handgrip strength) using dynamometer and physical performance using Short Physical Performance Battery (SPPB) is an appropriate, easy and reliable assessment.[11]

Several studies in Asia and Europe showed various results however there is no study has ever been done on the association between muscle mass and strength (handgrip strength) and physical performance assessed using Short Physical Performance Battery (SPPB) in Surabaya, therefore in this study we aim to assess the association between muscle mass and strength (handgrip strength) with physical performance assessed using Short Physical Performance Battery (SPPB) in the elderly community. This study is also a part of a study in sarcopenia and frailty profile in elderly community in Surabaya.

The general aim of this study is to analyze the association between muscle mass and strength (handgrip strength) with physical performance assessed using Short Physical Performance Battery (SPPB) in the elderly community in Surabaya. The results of this study can be used as a reference in promotive and preventive healthcare in the elderly community.

Material and Methods

This study was a cross-sectional observational analytic study. Samples included in this study were elderly of age $\geq$60 years old, registered in five *PosyanduLanjutUsia*(Elderly integrated health service)*Puskesmas*(Community Health Center) *Surabaya* consist of*PuskesmasMenur, PuskesmasSememi, PuskesmasPutat Jaya, Puskesmas Perak Timur*and*PuskesmasTambakRejo*who met the inclusion and exclusion criteria.

Inclusion criteria in this study were people of age $\geq$ 60 years old, willing to participate in this study and sign the informed consent. Exclusion criteria were limitations of mobilization (ADL $\leq$8, has difficulty to walk independently with/without assistive devices, arthritis, recent fracture), difficulty understanding the assessment instructions (MMSE<18), and unable to undergo examination (NYHA 3 and 4, RR>20x/minutes).

The subjects who met inclusion and exclusion criteria were examined sequentially: muscle mass, muscle strength (handgrip strength), and physical performance (SPPB) which conducted 10 minutes after examination of muscle strength (handgrip strength). The results were then tabulated and analyzed.

All data were analyzed using SPSS version 20 software. Bivariate analysis was performed using chi square test to determine the association between one variable with another. Multivariate analysis was performed on variables with bivariate analysis with $p<0.25$ to determine the association/influence of several independent variables with a dependent variable simultaneously. Multivariate analysis was performed using logistic regression test (SPSS 20.0 software).

Muscle mass

Muscle mass was a physical measurement of muscle using Bioimpedance Analysis (BIA) which is a device to measure fat volume and muscle mass without fat. Muscle mass is obtained from calculations of Appendicular Skeletal Mass (ASM) divided by the square of the height of the subjects (kg/m^2).[8] This study uses a cut-off value of muscle mass according to the AWGS recommendations adjusted to the measurements of 20 healthy young adult samples calculated with a value of -2SD obtained for men < 6.1 kg/m^2 and women <3.0 kg/m^2.

European Working Group on Sarcopenia in Older People (EWGSOP) recommended Dual-energy X-ray Absorptiometry (DXA), Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Bioimpedance Analysis (BIA) to assess sarcopenia. Recently the accuracy of DXA, CT and MRI is well known.[7] Accuracy of BIA in diagnosing sarcopenia has been validated, but is very dependent to the accuracy of the equipment equations and the assessment conditions, e.g. temperature, humidity, skin conditions, etc. However, due to high cost and a high exposure of radiation from Computed Tomography (CT), and due to inconvenience of screening, CT and Magnetic Resonance Imaging (MRI) have limited application despite being the gold standard of whole-body composition evaluation. On the other hand, Dual-energy X-ray Absorptiometry (DXA) is also thought to be an appropriate alternative approach to distinguish between fat, bone mineral and tissue.[12]

Now, DXA is probably the most used device in measuring muscle mass in studies about sarcopenia. DXA has minimal radiation exposure but using DXA in community screening is still challenging. A BIA tool model was developed than; which has superiority to obtain appendicular muscle mass measurements with precise results. BIA tool is easy to carry, affordable cost, faster processing, non-invasive, radiation-free, and is convenient to use, therefore is the right tool to measure sarcopenia in the community. The results of fat-free mass estimation of several segments using BIA are strongly related to using DXA among the elderly in Taiwan.[9]

A study in Asia stated that BIA tool is the most used tool to measure sarcopenia and the measurement results of BIA is consistent. BIA tool is easy to carry and affordable, therefore BIA is considered to be the main approach to screen sarcopenia in the community. Therefore the Asian Working Group for Sarcopenia (AWGS) supports the use of BIA to diagnose sarcopenia and evaluate the effects of intervention program, however AWGS recommended to provide variance coefficients, also inter and intra-examiner reliability evaluation to facilitate international comparisons in the future.[1]

Muscle strength

Muscle strength was defined as the maximum strength of muscle to hold a load. Thehandgrip muscle strength was measured using hand dynamometer Takei Physical Fitness Test and expressed on a number scale indicated by the peak hold needle in kilograms (kg) so that there was no bias in the measurement. The procedure was the following: before measurement, make sure the subject's hands were dry; the subject stands relaxedwith their arms straightened down while holding the instrument with their dominant hand. Next, subject was instructed to pull the

handgrip handle with all strength, avoid the arm touching the body, and no swinging or pumping. Measurementswere done three times on the dominant hand, with 30-second rest, and the highest value was taken as the handgrip strength. Weak handgrip strength according to AWGS is <26 kg for men and <18 kg for women.[13]

EWGSOP recommends several ways to measure muscle strength including: handgrip strength, knee flexion/extension and peak expiration. AWGS recommends using the handgrip strength to measure muscle strength in either research or clinical practice. The handgrip strength has been widely used in Asia.[8]

Physical performance

Physical performance was defined as a form of mobility which is a part of physical function.[14] Short Physical Performance Battery (SPPB) is a physical performance test to evaluate balance, walking speed, strength, and endurance by assessing individual's ability to stand in side-by-side feet position, semi-tandem and tandem position, time to walk 8 feet and time to stand from a chair and back to sitting 5 times.SPPB score is the sum of scores on three tests: balance, gait speed, and chair stand. Each test is given the same weight as a score, between 0 and 4. The maximum score on the SPPB is 12. SPPB 0–6 meansthe physical performance is low, SPPB 7–9 means the physical performance is moderate and SPPB 10–12 means physical performance is high.[7]

Mobilization Limitations

Mobilization limitations were defined as study subjects who clinically have difficulties in the form of severe impairment with Barthel index of (ADL ≤ 8) and/or having difficulties in walking independently with/without aid, arthritis or recent fracture.[15]This was meant to be the exclusion criteria in this study.

Difficulties in Understanding the Instructions

Difficulties in understanding the instructions were defined as study subjects with difficulties in understanding examination instructions since clinically they had intellectual disturbances and/or severe cognitive impairment with MMSE score < 18.[15] This was meant to be the exclusion criteria in this study.

Unable to Participate in Examinations

Unable to participate in examinations were defined as study subjects with inability to participate in examinations due to clinical complications such as severe cardiovascular diseases (NYHA class III and IV and high respiratory rate that is more than 20 times per minute (tachypnea).[16]This study was the exclusion criteria.

Comorbidities

Comorbidities were defined as clinical conditions or diseases that can cause, complicated, or coincidence in the beginning or in the clinical course of the subjects. In this study the comorbidities were based on *Cumulative Illness Rating Scale* (CIRS).

Nutritional Status using MNA Score

MNA score or short for Mini Nutritional Assessment is a method used to determine the subjects' nutritional status whether they were normal, at risk for malnutrition, or malnourished.

Barthel Activity Daily Living (ADL)

Barthel Activity Daily Living (ADL) is used to determine daily living activity capability such as walking, eating, putting on clothes, taking a bath, cleaning themselves, moving from lying down to sitting, controlling the urge to urinate and defecate, and using the toilet. This study excluded ADL ≤8 which means severe and total dependence.

Mini Mental State Examination (MMSE)

Mini Mental State Examination (MMSE) is a method used to determine the cognitive functions. MMSE score ranged from 0 to 30.The exclusion criteria in this study was MMSE score < 18.

Physical Activity Scale Of The Elderly (PASE)

Physical Activity Scale Of The Elderly (PASE)is used to determine Daily Physical Activity such as walking outside house, light exercises (elderly gymnastic), moderate exercises (fishing, fast walking, double-tennis), strenuous exercises (single sport, moderate-fast pace aerobic exercise, swimming, muscle strength (weightlifting, push up, light housework (washing the dishes), strenuous housework (mopping), painting the wall/wiping windows, cleaning the garden, outdoor gardening, taking care of other people, and working status.

Result

The subjects of this study were 203 elderly mainly consist of women as much as 146 (71.9%) and the rest were men as much as 57 (28.1%). The mean of the age was 64 years old with the age ranging from 60 to 86 years old. Most of the subjects that consist of 118 (58.1%) people were not working. The adequacy of living costs/sufficient economy status was found in 156 subjects (76.8%). There were 136 (67%) subjects routinely exercised and 193 (95.1%) subjects did not have a history of consuming vitamin D. The profile of the subjects acquired were 144 (70.9%) independent subjects, 161 (79.3%) subjects had no cognitive impairment, 144 (70.9%) were not malnourished, 76 (37.4%) had normal BMI, 116 (57.1%) had low physical activity. The main comorbidity based on Cumulative Illness Rating Scale (CIRS) was musculoskeletal condition on 137 (67.5%) subjects.

The subjects mainly had poor muscle mass 122 (59.1%), mainly had strong muscle strength (handgrip strength) 122 (60.1%) and moderate physical performance of Short Physical Performance Battery (SPPB) 90 (44.3%).

There was no correlation between muscle mass and physical performance (SPPB) with p=0.52. However, there was a correlation between muscle strength (handgrip strength) and physical performance (SPPB) with correlation value of r = 0.26 (p<0.001) that showed positive correlation with weak correlation. The table showed that although the muscle mass was poor the physical performance (SPPB) was still good.

Figure 1 showed that there was positive correlation between muscle strength (handgrip

strength) and physical performance (SPPB). The stronger the muscle strength (handgrip strength) was, the higher the physical performance (SPPB) will be. This was in accordance with the theory which states that increased muscle strength will increase physical performance (SPPB) which consists of balance test, walking pace, and sit to stand test so that this result was consistent with the previous study which states that there is correlation between muscle strength and physical performance (SPPB).

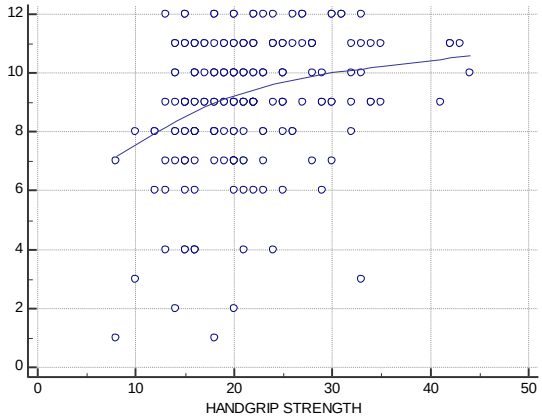

Figure I. The representation of muscle strength (handgrip strength) with physical performance (SPPB)

This study showed that there was no correlation between muscle mass and physical performance (SPPB) with p value of 0.517 and the correlation between muscle strength (handgrip strength) and physical performance (SPPB) with p value of 0.001 so that the statistical analysis of this study will not be continued to multivariate logistic regression analysis.

Discussion

This study had a quite big difference in the amount of women and men enrolled, with women being the most of them. This is in accordance with the data from Central Bureau of Statistics East Java which stated that there was an increased in the number of elderly population up to year 2017 the number reached 236.541 (8.23% from total population), 51.59% were women and 48.1% were men.[17] A study in Italy suggested that serum vitamin D level has significant correlation with SPPB and muscle strength (handgrip strength) both in men and women. In this study most subjects did not consume vitamin D and suffer from most musculoskeletal comorbidities so that it affects the subjects' physical performance. The subjects of the study were mostly independent; this will indirectly affect the physical performance of the subjects. Moderate level of SPPB was mostly obtained in accordance with the result of the study which showed that most of the subjects were independent but had low PASE and musculoskeletal comorbidities. Mini Mental State Examination(MMSE) score of the subjects were mostly normal and not depressed according to normal Geriatric Depression Scale (GDS) score. A study in America showed a significant correlation between muscle strength (handgrip strength) and MMSE score with p value of $p < 0.001$. A study in Japan suggested that nutritional status indirectly influence physical performance (SPPB) and ADL. Poor nutritional status accompanied by comorbid diseases will decrease insulin-like growth factor production causing a decrease in muscle strength and physical performance.[18]A study that was conducted in America suggested that there is significant correlation between BMI and skeletal muscle mass both in men and women. This is consistent with the result of this study that subjects with normal MNA had strong muscle strength (handgrip strength), independent ADL and moderate SPPB. Low

Daily Physical Activity was linked with low quality of life in elderly community. A study that was conducted in Austria showed that PASE had significant correlation with balance skills, gait speed, and chair stands that were part of Short Physical Performance Battery (SPPB).[19] A study in America also showed that physical activity had significant correlation with SBB.[20] The subjects of the study were mainly consist of low Physical Activity Scale of the Elderly (PASE) and not working, but had moderate SPPB, this is perhaps caused by certain factors such as independent ADL, normal MNA and normal MMSE.

Metabolic changes in aging process consist of decreased muscle protein synthesis, increased insulin resistance, and increased body fat mass. The decreased basal metabolic cause the muscle mass to decrease.[5,21] Some studies showed that age, sex, ethnicity, body weight, BMI, protein intake, vitamin D level and physical activity affect muscle mass.[1] A study in America showed that there is significant correlation between BMI and skeletal muscle mass 47.9 %, with $p < 0.05$ in women and 50.1 % with $p < 0,05$ in men.

Other factors contributing to muscle mass decrease are decreased alpha motor neuron, low steroid hormone levels, low protein intake and decreased physical activity. In accordance with the previous study, in this study we also concluded that low muscle mass is related to age, sex and low physical activity. A cross sectional study that was conducted in Portuguese that measured muscle strength (handgrip strength) in elderly population ≥65 years old, showed that men had strong muscle strength (handgrip strength) compared to women with p value < 0.001.[22] A study in Asia showed that muscle strength (handgrip strength) will decrease along with increasing age in all ethnicity and sex with $p < 0.001$.[23] Age-related muscle strength reduction is caused by decreased contractile protein (reduction of muscle fiber caused by muscle and/or nerve alteration), decreased muscle ability to change muscle fibers length and the ability of central nervous system to activate normal motor neuron unit or a combination between those mechanisms. Grimby and Saltin suggested that decreased muscle strength in elderly occur because of a reduction in the amount of muscle fibers and not the quality. This theory was also declared by Lexell et al. that decreased muscle fibers in vastus lateralis muscle account for 40 % and the amount of muscle fibers was 39% from 20 to 80 years old. The muscle fibers decreased but the amount can still comply the smallest muscle size needed. Poor nutritional status accompanied by comorbid diseases will decrease the insulin-like growth factor production, causing a decrease in muscle strength and physical performance.[18] Consistent with this study, strong muscle strength was obtained with normal MNA and MMSE.

A study in Europe showed that muscle strength (handgrip strength) of men and women will decrease after 45 years of age and also a decrease in chair stand test as a part of Short Physical Performance Battery (SPPB) both in men and women.[24] This study was in accordance with the previous study that showed that moderate Short Physical Performance Battery (SPPB) was obtained with strong muscle strength (handgrip strength), independent ADL and normal MNA. A decrease in endocrine system function as a part of aging process cause decreased Growth Hormone (GH), Insulin-like growth factor-1 (IGF-1), estradiol, testosterone, and

Dehydroepiandrosterone (DHEA) that are needed for muscle fibers proliferation causing a decrease in protein metabolism and finally a decrease in muscle mass and eventually the physical performance. However, there was no correlation between muscle mass and physical performance (SPPB) with p = 0.517. A study in Asia also had similar result that showed no correlation between muscle mass and physical performance (SPPB) in elderly both in men and women.[4]In this study it was possible that there was a correlation between age and sex, although there was poor muscle mass, the physical performance (SPPB) was good because the MNA and BMI were normal.

In this study there was a significant correlation between muscle strength (handgrip strength) and physical performance (SPPB) with p = 0.001. A study in Asia showed that low extremities muscle strength was significantly correlated with physical performance (SPPB), both in men (OR 0.950; p = 0.012) and women (OR 0.107; p = 0.020).[5] A cohort prospective study carried out by Legrand et al., 2013 in Belgium also suggested that there was a correlation between muscle strength (handgrip strength) and physical performance determined by SPPB in elderly of the community.[6]Studies in Canada and Brazil analyzed SPPB as a screening test in frailty subjects in the elderly community. The study results showed the cut-off value of 9 in SPPB had the best score which were sensitivity of 92% and specificity 80%. Bandinelli et al also used cut-off value of 9 and showed the SPPB scores affected the outcome of the study subjects. The same results are also shown by Verghese and Xue using cut-off value of 8 with sensitivity was 52% and specificity was 70%, and Vasunilashorn et al using cut-off value 10 with sensitivity 69% and specificity 84%.[25]

In the aging process, pro-inflammatory cytokines will increase the myosin protein and reticulum sarcoplasm will decreasecausing a decrease in type 2 muscle fibers affecting the skeletal muscle contraction so that the muscle strength and physical performance will decrease. A cohort study done by Hughes et al. in England showed that after being followed for 12 years, a decrease of the front thigh muscle will significantly correlated with the diminished knee extension ability in elderly men. Muscle strength exercise program was a standard rehabilitation technique to increase muscle strength in elderly men. This exercise will cause muscle hypertrophy due to an increase in the size of type 1 and type 2 muscle fibers. Muscle hypertrophy also causes an increase in actomyosin protein. This mechanism can become a part of increased muscle mass in elderly people and some of muscle strength enhancement caused by muscle hypertrophy. A study in America showed a significant correlation between muscle strength (handgrip strength) and MMSE score with p < 0.01. Consistent with the previous study, this study also showed strong muscle strength with moderate physical performance (SPPB) and normal MNA and MMSE.

The limitations of this study is this observational cross section study was done in one time causing it unable to depict the subjects clinical course, data and comorbidities were obtained only through interviews and physical examination and did not consider the corresponding factors.

Conclusion

There is a positive correlation between muscle strength (handgrip strength) and physical performance (SPPB) with weak correlation and there is no correlation between muscle mass and physical performance (SPPB) in elderly community in Surabaya. Muscle strength (handgrip strength) plays a role in physical performance (SPBB) in elderly subjects.

Further studies are needed to understand the correlation of muscle mass and muscle strength (handgrip strength)with physical performance in elderly community determined using other physical performance test (usual gait speed, get-up-and-go-test), and to understand factors affecting the muscle mass, muscle strength (handgrip strength) with physical performance in elderly community such as nutritional status (MNA/BMI), endocrine system (GH, IGF-1), testosterone, and DHEA), PASE, ADL and Vitamin D level so that we can determine which factors play the biggest role.

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