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# Relationship between Testosterone levels with Hand Grip Strength, Calf Diameter, Lung Function, Body Mass Index and Blood Pressure in Elderly Men

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**Keywords**

*Hand grip strength, calf diameter, lung function, BMI, blood pressure*

**ABSTRACT**

*The elderly population in Indonesia is increasing every year. Aging is associated with loss and decline in testosterone levels in elderly men. Testosterone deficiency is associated with decreased body mass, decreased bone density, decreased physical function and activity, decreased cognitive function, increased fat mass, increased depressive symptoms and increased risk of falls and fractures. Muscle mass is the largest tissue which covers 40%-50% of the body. To assess muscle strength, hand grip strength can be measured and to assess muscle mass, anthropometric measurements can be made, especially calf diameter. While for body fat can be measured body mass index. The age-related decrease in skeletal muscle mass also affects respiratory muscle function which can be seen from the decline in lung function (FEV1 and FVC). In addition, increased blood pressure is also common in elderly people. Objective: To determine the relationship between the hormone testosterone with hand grip strength, calf diameter, lung function, body mass index (BMI) and blood pressure in elderly men. Method: This study is observational analytic with a cross-sectional study design conducted in Manado on elderly men. Results: From this study, 38 samples of elderly men were obtained who had a significant positive relationship between testosterone levels and FVC values (p = 0.004). There was a significant positive relationship between testosterone levels and the strength of the right-hand grip (p = 0.245) and left-hand grip (p = 0.354), the same was true for FEV1 values (p = 0.078) and systole (p = 0.340) and diastole (p = 0.216). In this study there was a significant negative relationship between testosterone levels with the diameter of the right calf (p = 0.009) and left (p = 0.009) and the same thing also in the BMI value (p = 0.003). Conclusion: The better the testosterone level, the better the FVC value, while the lower the testosterone level, the greater the calf diameter and BMI. FEV1 values, hand grip strength and blood pressure were not significantly affected by testosterone levels.*



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## INTRODUCTION

Decreased muscle strength, muscle mass, and muscle function are influenced by various factors including aging, lack of nutrition, hormonal factors, metabolic factors, immunological factors, along with decreased units and muscle fibers accompanied by muscle atrophy can also play a role. In men in particular, muscle mass is related to testosterone levels. Testosterone stimulates mitosis in myoblasts and increases the number of satellite cells that synthesize proteins (Dalbo et al., 2017). Testosterone also stimulates ribosomal activity, RNA polymerase synthesis and increases the synthesis of contractile and non-contractile muscle proteins and all of these affect muscle mass. Skeletal muscle mass is the largest tissue in the human body which accounts for 40% - 50% of the total body mass. Body mass can be divided into two major parts namely as body fat and fat-free mass including muscle, organs and bones. The most common measurement of body fat is by body mass index (BMI).

Increasing age causes changes in body composition, including decreased skeletal muscle mass and increased total and abdominal fat mass(Chen, Chung, Chen, Ho, & Wu, 2017).9,10 In addition, with aging, there is a decrease in physiological capacity, including control of respiratory ventilation, respiratory muscle strength, respiratory mechanisms, and gas exchange. Changes in the respiratory mechanism are further evident with a decrease in physiological capacity during the aging process, which includes a progressive increase in chest wall stiffness and a decrease in the elastic component of the lung. In the lungs there is a loss of synovial joints between the sternum and the chest wall cartilage, thereby reducing chest wall compatibility and tension forces that cause a decrease in maximal respiratory pressure and a decrease in muscle mass and strength of additional respiratory muscles.

Assessment of muscle strength is done by measuring hand grip strength and for muscle mass measurement is done by calf circumference (Landi et al., 2017). Changes in skeletal muscle associated with age may affect respiratory muscle function, and a positive correlation was found between hand grip strength and inspiratory and expiratory muscle strength (Kim, 2018). There was a decrease in skeletal muscle mass and strength including respiratory muscles, in particular a decrease in lung function forced expiratory volume and forced vital capacity (FEV1 and FVC) associated with decreased muscle mass. In the elderly an increase in blood pressure is frequent, due to a reduction in the elasticity of the arteries or there has been a process of sclerosis especially in large arteries and can also be caused by other secondary causes.

## METHODS

By means of cross-sectional studies, this research was conducted at geriatric outpatient RSUP Prof.dr.R.D.Kandou and elderly homes in North Sulawesi Province, Manado. The study was conducted for 6 months from January - June 2019. With the inclusion criteria of this study are male patients, aged from 60-75 years, have no history, symptoms, and signs of lung disease, do not have diabetes, do not have acute infections clinically, do not exercise actively, have never smoked or ever smoked < 1 year, Mini Mental State Examination (MMSE) score ≥ 24, able to carry out hand grip strength checks and forced spirometry; exclusion criteria are patients with impaired consciousness, patients have contraindications to spirometry examination according to the Association for Respiratory Technology and Physiology Guideline. All research patients who were the subjects of the study underwent an examination process in the form of history and standard physical examination as well as assessment with MMSE scores. After the screening test, x-ray examination of the thorax, blood sugar, hand grip strength using a hand grip dynamometer, calf diameter using a meter, testosterone levels, spirometry, and BMI.

## RESULTS

The result data can be seen in the following table:

Table 1. Sample characteristics

| Characteristics | N | Minimum | Maksimum | Mean | Standard intersection |
|---|---|---|---|---|---|
| Age | 38 | 60 | 75 | 65.95 | 3.925 |
| TD Sistol (mmHg) | 38 | 100 | 160 | 126.32 | 14.505 |
| TD Diastol (mmHg) | 38 | 70 | 100 | 78.95 | 9.091 |
| IMT (kg/m$^2$) | 38 | 18.7 | 34.6 | 25.68 | 3.758 |
| Testosterone (ng/dL) | 38 | 265 | 1075 | 559.53 | 183.476 |

| | | | | | |
|---|---|---|---|---|---|
| KGT Right (kg) | 38 | 18.1 | 50.2 | 35.01 | 6.821 |
| KGT Left (kg) | 38 | 15.0 | 46.9 | 31.06 | 6.828 |
| DB Right (cm) | 38 | 30.0 | 43.5 | 37.03 | 3.596 |
| DB Left (cm) | 38 | 30.0 | 43.5 | 37.14 | 3.498 |
| FEV1 (%) | 38 | 46 | 117 | 81.84 | 13.972 |
| FVC (%) | 38 | 43 | 100 | 74.50 | 12.869 |

n = number of research samples; KGT = hand grip strength; DB = calf diameter

**Relationship of Testosterone Levels with Hand Grip Strength (KGT in Elderly Men)**

With the Pearson correlation test between testosterone levels with the right KGT (r = 0.115, p = 0.245) and the left KGT (r = 0.063, p = 0.354). Indicates a positive relationship that is not meaningful.

| Relationship variable | n | Coefficient correlation | Significance |
|---|---|---|---|
| Testosterone - KGT Right | 38 | r = 0,115 | p = 0,245 |
| Testosterone - KGT Left | 38 | r = 0,063 | p = 0,354 |

Information: Pearson correlation test

**Relationship of Testosterone Levels with Calf Diameter in Elderly Men**

With the Pearson correlation test between testosterone levels with right DB (r = -0.383, p = 0.009) and left DB (r = -0.382, p = 0.009). Shows a meaningless negative relationship

| Relationship variable | n | Coefficient correlation | Significance |
|---|---|---|---|
| Testosterone - DB Right | 38 | r = -0,383 | p = 0,009 |
| Testosterone - DB Left | 38 | r = -0,382 | p = 0,009 |

Information: Pearson correlation test

**Relationship of Testosterone levels with FEV1 values in elderly men**

With the Pearson correlation test between testosterone levels and FEV1 (r = 0.2355, p = 0.0078). Shows a meaningless positive relationship

| Relationship variable | n | Coefficient correlation | Significance |
|---|---|---|---|
| Testosterone – FEV1 | 38 | r = 0,235 | p = 0,078 |

Information: Pearson correlation test

**Relationship of Testosterone levels with FVC values in elderly men**

With the Pearson correlation test between testosterone levels and FVC (r = 0.421, p = 0.004). Demonstrate meaningful positive relationships

| Relationship variable | n | Coefficient correlation | Significance |
|---|---|---|---|
| Testosterone – FVC | 38 | r = 0,421 | p = 0,004 |

Information: Pearson correlation test

**Relationship between testosterone levels and BMI values in elderly men**

With the Pearson correlation test between testosterone levels and BMI (r = -0.437, p = 0.003). Demonstrate meaningful positive relationships

Table 6. Results of the analysis of the relationship between testosterone levels and BMI values in elderly men

| Relationship variable | n | Coefficient correlation | Significance |
|---|---|---|---|
| Testosterone - IMT | 38 | r = -0,437 | p = 0,003 |

Information: Pearson correlation test

**Association of testosterone levels with systole blood pressure and diastole blood pressure in elderly men**

With the Pearson correlation test between testosterone levels with TDS (r = 0.069, p = 0.340) and with the spearman correlation test between testosterone and TDD (r = 0.059 , p = 0.724). Indicates a positive relationship that is not meaningful.

| Relationship variable | n | Coefficient correlation | Significance |
|---|---|---|---|
| Testosterone - TDS | 38 | r = 0,069 | p = 0,340 |
| Testosterone - TDD | 38 | r = 0,059 | p = 0,724 |

Information: Pearson correlation test performed on testosterone with TDS
Spearman correlation test performed on testosterone with TDD

**Discussion**

In this study, 38 samples of men aged 60 years to 75 years, specifically this study was conducted in the elderly population. This is in accordance with Law of the Republic of Indonesia Number 13 of 1998 which states that elderly is someone who has reached the age of 60 years and over.17 In Indonesia, especially in old age, hypertension is very common(Sujarwoto & Maharani, 2020). In 38 samples of this study, 21 samples were hypertensive patients and 17 samples were non-hypertensive, which had systole blood pressure varying from 100 mmHg to 160 mmHg and diastole blood pressure varying from 70 mmHg to 100 mmHg. This is because in old age often experience a reduction in the elasticity of the arteries or sclerosis processes, especially in large arteries. 18 Indonesians have a lower cut-off point of skeletal muscle mass than other ethnic groups where body fat is higher with smaller skeletal muscle mass. Skeletal muscle mass is the largest tissue in the human body, accounting for 40%-50% of total body mass.7 Body m(Dulloo, Jacquet, Solinas, Montani, & Schutz, 2010)ass can be divided into two major parts: body fat (energy reserves) and fat-free mass (including muscles, organs and bones).8 The most commonly measured measure of body fat is BMI.18

In 38 samples of this study, BMI results were obtained in the form of 11 samples were normoweight participants, 4 samples were overweight participants, 18 samples were obese participants I and 5 samples were obese II participants, which had a body mass index that varied from 18.7 kg / m2 to 34.6 kg / m2. According to Ranasinghe et al from Sri Lanka 2013 18 both in men and women found an increase in body fat in line with increasing age, in their research also showed a positive correlation between BMI and body fat and in accordance with previous studies. Body fat in both men and women increases with age, with women having higher body fat than men in old age(Davison, Ford, Cogswell, & Dietz, 2002).18 In the Pearson correlation test, this study showed a significant negative relationship between BMI values and testosterone levels (r = -0.437 with p = 0.003). These results show that the lower the value of testosterone levels will tend to be greater a person's BMI or vice versa, the greater a person's BMI will tend to be lower the value of testosterone levels as in this study where the average sample was at the limit of Obese I BMI with an average of 25.68 kg / m2. In the aging process (aging) some changes can occur in various body systems, such as the endocrine system, one of which is a decrease in the hormone testosterone(Vitale, Salvioli, & Franceschi, 2013).4,11,19,20 Testosterone is an anabolic steroid that functions to maintain bone mass, muscle mass and function, and composition of the body(Sinclair, Grossmann, Hoermann, Angus, & Gow, 2016). Testosterone deficiency is associated with decreased body mass, bone density, increased fat mass with changes in body fat composition, decreased physical function and activity(Saad, Roehrig, von Haehling, & Traish, 2017).21 Testosterone is associated with muscle mass and muscle strength, where muscle cells respond to high testosterone levels by increasing muscle size and muscle strength, through stimulated receptors that cause protein synthesis.21 This has been demonstrated in research by Auyeung et al,22 that testosterone has a relationship to muscle quantity and muscle quality. Where has a positive relationship with muscle mass and is related to muscle strength and physical performance depending on muscle mass. In the Pearson correlation test, this study showed a positive relationship between right hand grip strength and testosterone levels but not statistically significant (r = 0.115 with p = 0.245) and results on left hand grip strength with testosterone levels also had a positive but not statistically meaningful relationship (r = 0.063 with p = 0.354). This study is not statistically significant, because there are still factors that can affect hand grip strength other than testosterone levels that are closely related to age group, anthropometry, health status, nutritional status, physical activity and socioeconomic status.5 Large calf diameters reflect better functional ability in elderly patients and also reflect better muscle mass and strength.27 This has been shown in studies by Tsai et al in Taiwan in 2017,27 that calf diameter is significantly related to physical function, and has good performance function in elderly patients. In the Pearson correlation test, this study showed a significant negative relationship between right calf diameter and testosterone levels (r = -0.383 with p = 0.009) and a significant negative relationship between left calf

diameter and testosterone levels (r = -0.382 with p = 0.009). Controversy with these results shows that the lower the value of testosterone levels will tend to be the larger the diameter of the calf or vice versa, the larger the diameter of the calf will tend to be lower the value of testosterone levels as in this study where the average sample was at the limit of BMI Obese I with an average of 25.68 and a standard intersection of 3.758. So On subjects with obesity found larger calf diameters but negatively correlated with testosterone levels(Tuttle, Sinacore, & Mueller, 2012). In a study by Shin et al in 2018, that decreased skeletal muscle mass where body fat including the entire body as a whole (intraabdominal and intramuscular fat) decreased, this was associated with loss of function from physical activity and disability.28 According to Wattimena et al in Bandung in 2017, 7 the skeletal muscle mass of Indonesians is lower than other ethnic groups, where body fat is higher with smaller skeletal muscle mass. For this reason, differences in body shape, bone skeleton and leg length are some of the factors that cause low limit points of skeletal muscle mass(Heymsfield, Peterson, Thomas, Heo, & Schuna Jr, 2016). The relationship between testosterone and muscle mass and its function has not been explained, but it is known that both decline with age(Curtis, Litwic, Cooper, & Dennison, 2015).17 This could be a new aspect given that there is no reference to measuring testosterone levels directly with calf diameter, there may be a relationship between low skeletal muscle mass and fat in muscle based on BMI where there is a negative relationship with testosterone levels. In the Pearson correlation test, this study showed a significant negative relationship between BMI values and testosterone levels (r = -0.437 with p = 0.003). These results show that the greater the BMI value, the lower the value of testosterone levels as in this study. This is in accordance with research by Osuna et al in 2006,87 that there is a significant negative relationship between testosterone levels and BMI values in the obese group than the overweight group or normal group. The same thing too dikemukakan oleh Shamim dkk di Pakistan tahun 2015.30 With age, the respiratory tract in the lungs is more prone to collapse and there is a decrease in physiological capacity including FVC, FEV1 and FEF.3,12,13,14,15,31 Changes in skeletal muscle associated with age may affect respiratory muscle function. Loss of synovial joints between the sternum and chest wall cartilage leads to decreased chest wall expansion and chest wall stiffness leading to a decrease in maximal respiratory pressure and decreased muscle mass accompanied by decreased strength from additional respiratory muscles.1,3,32 In the Pearson correlation test, this study showed a positive relationship between testosterone levels and FEV1 values but was not statistically significant (r = 0.235 with p = 0.078) and found an association significant positive between testosterone levels and FVC values (r = 0.421 with p = 0.004). Changes in the respiratory mechanism are evident in the decrease in physiological capacity during the aging process, which also includes a progressive increase of chest wall stiffness and a decrease in the elastic component of the lungs. 1,3,11 According to Mawi et al,33 there is a significant relationship between the value of testosterone levels and lung function measured through FEV1 and FVC values.

Increased blood pressure (hypertension) often occurs in the elderly, due to a reduction in arterial elasticity or there has been a process of sclerosis especially in large arteries and can also be caused by other secondary causes.16 In this study there were mixed samples with hypertensive and non-hypertensive patients. In the Pearson correlation test, this study showed a positive relationship between systole blood pressure and testosterone levels, but not statistically significant (r = 0.069 with p = 0.340) and in diastole blood pressure (r = 0.059 with p = 0.724). In this study for non-hypertensive samples also have a positive but not meaningful relationship, the same was obtained in the research of Agbecha et al in Negeria in 2018,34 in a normotensive sample study there was no significant relationship while for prehypertension had a significant negative relationship while the relationship between testosterone and blood pressure had a positive but not meaningful relationship, This may be because most (21 out of 38 people) patients with hypertension in this study had their blood pressure controlled, so further research is still needed for the relationship between testosterone levels and hypertensive patients.

The limitation of this study is the absence of age grouping with sufficient sample distribution based on BMI and blood pressure categories in both hypertensive and nonhypertensive patients(Pilakkadavath & Shaffi, 2016). The advantage of this study is that no research has ever been conducted on measuring testosterone levels that are associated with calf diameter directly.

## CONCLUSION

It was found that a positive linear relationship was not meaningful between testosterone levels with right and left-hand grip strength, fev1, and systole and diastole blood pressure, the higher the testosterone hormone levels, the greater the right and left-hand grip strength, fev1, and systole and diastole blood pressure but not significant in elderly men in this study. It was found that a significant positive linear relationship between testosterone levels and FVC values, the higher the testosterone levels, the higher the FVC values in elderly men in this study (lenoir et al., 2020). It was found that a significant negative linear relationship between testosterone levels and bmi and calf diameter (right and left), the lower the testosterone levels, the greater the bmi and calf diameter (right and left) in obese elderly men. It was found that almost 90% of

testosterone levels in elderly men in manado were found to be within normal low limits, but there was a significant relationship between testosterone levels with calf diameter, bmi and fvc values. Advicein elderly men with normal or controlled blood pressure can be considered for the administration of testosterone hormone replacement (THR) hormone replacement therapy (THR) especially in obese patients to increase muscle strength, especially calf muscles, lung function and to reduce BMI.

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