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The Relationship between the Body Circumference and Health Status of Elderly Women: The Usefulness of Calf Circumference Measurement

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As people age, physical and physiological changes occur, including an increased risk of osteoporosis and fractures, and decreased muscle tone. These symptoms can be confirmed by regular check-ups, however, the physical examination method is considered to be a more economic and effective way to assess these symptoms. The objective of this paper is to analyse the relationship between body circumference, physical fitness, lung capacity, and sarcopenia risk factors with the predictors of elderly women's health status. Initially, 143 women (over 65 years) enrolled in and completed this study; however, the final study group consisted of only 131 participants, as 12 participants withdrew. We used the G-Power 3.1 program for statistical analysis. The effect size, significance level, and power were set at 0.3, 0.05, and 0.90, respectively. Firstly, CC showed the highest positive correlation with muscle mass, SMM, and lean body mass, and the least positive correlation with the obesity index. Secondly, CC had a positive correlation with grip strength and dynamic balance. Thirdly, CC had a negative correlation with SBP and a static correlation with ASM, FEV,1 and PEF. Fourthly, the decrease in SLM and SMM was 6 times higher in the case of sarcopenia risk, and the risk of sarcopenia was over 15.54 times higher for those over 80 years of age. Based on the above results, our conclusion is that CC has the potential to predict physical health and exercise function. This measurement method is simple, inexpensive, and advantageous as a measurement tool. The application of various simple measurement tools and the identification of predictors of different diseases (including sarcopenia risk factors) needs to be developed; this seems to be an area for further research in the future.

Key words: *Body circumference, Calf Circumference, Elderly women, Health status, Physical fitness, Sarcopenia.*

Introduction

The number of senior citizens worldwide is increasing, especially in Sub-Saharan Africa, where the population of people over the age of 60 will rise from 44 million in 2015 to 111 million in 2050 (Organization, 2017). The ageing population in Korea is also increasing. Therefore, health maintenance is becoming a very crucial factor for enhancing life. Alongside aging different physical and physiological changes occur, including an increased risk of osteoporosis and fractures, and decreased muscle tone. Physical examination, physical function evaluation, and anthropometric measurements can be used as an economic and effective method to identify these symptoms. Anthropometric indicators' include height, weight, body circumference, and body mass index (BMI). (Sánchez-García et al., 2007). These anthropometric indicators are effective in predicting and analysing the health status, human body changes, and disease risk in older adults (Muñoz et al., 2010).

Calf circumference (CC) is related to lean body mass (LBM) and is an anthropometric measurement factor for the risk of disability in elderly people (Sun et al., 2017). Recent studies have reported that a lack of muscle mass puts elderly people at a higher risk for respiratory and cardiovascular diseases (Kalyani et al., 2014). A positive correlation has been reported between CC, BMI, triceps skin folds, arm and middle arm circumference, and middle arm muscle, suggesting that CC can be used as an anthropometric measurement to monitor the nutrition of aging people (Portero-McLellan et al., 2010). CC can be diagnosed as 'sarcopenia'. A total of 657 Korean elderly people (70-84 years) were reported to have a proportional total muscle mass and CC. The CC cut-off value for sarcopenia was less than 32 cm, and the area under the curve on testing the CC validity of low muscle mass for males and females was 0.82 and 0.72 respectively (Kim et al., 2018). Thus, CC plays a crucial role in body measurements and ageing. Nevertheless, CC is an anthropometric measurement method that is used less commonly than other measurement methods.

In turn, similar to CC, elderly health is also related to changes in body composition, which can be confirmed by health status predictors (He et al., 2018). Body composition measurements are related to the skeletal muscle index (SMI), appenidicular skeletal muscle mass (ASM), fat-free mass (FFM), and percent body fat (PBF). In addition to body composition, a decrease in muscles leads to a decrease in muscle strength (MS) in elderly people. Such may cause physical weakness, physical disabilities, and varied diseases including type 2 diabetes (Park et al., 2006).

Therefore, the objective of this paper is to analyse the relationship between body circumference and physical fitness (PF), lung capacity, sarcopenia risk factors, and health status predictors in elderly women.

Materials and Methods

Study population

Table 1: Participants' physical characteristics of (M±SD).

Variable	n = 131
Age (years)	73.06 ± 5.55
Height (cm)	152.37 ± 5.18
Weight (kg)	59.60 ± 7.43
BMI (kg/m^2)	25.64 ± 2.56
SLM (kg)	35.22 ± 3.77
SMM (kg)	20.72 ± 2.37
FFM (kg)	38.21 ± 4.17
PBF (%)	35.57 ± 4.16

BMI: body mass index. SLM: soft lean mass. SMM: skeletal muscle mass. FFM: fat free mass. PBF: percent body fat.

This study recruited elderly women (over 65 years) living in Jeju Island, Korea, between June 3 and June 14, 2019. To recruit subjects, we visited the life sports program and presented the study's objective and method. We provided oral and written statements on how we would handle personal information collected during the study and stated that such would only be used for the study objectives.

Initially, 143 people participated in the study. However, because 12 people withdrew from the study, the final measurements analysed the data of 131 participants. By using the G-Power 3.1 program, the study was set to a 0.3 effect size, a 0.05 significance level, and a 0.90 power. This result was calculated using data from 109 people and it was confirmed that these participants were satisfied. The participants' physical characteristics are shown in Table 1.

Measurement items and methods

Physique (body composition) test

Height and weight were measured using an electronic height scale referred to as BSM370 (InBody CO., LTD., Korea). BMI was calculated by dividing the participants' measured weight (kg) by their height squared (m^2). Body composition tests were measured by the bio-electrical impedance analysis (BIA) method, using InBody370 (InBody CO., LTD., Korea) to

measure participants' soft lean mass (SLM), skeletal muscle mass (SMM), LBM, body fat mass (BFM), and PBF. The body circumference was calculated by the circumference of the participants' upper arm, waist, thigh, and calf, where the average was measured twice. Waist-Circumference-to-Height Ratio (WHtR) was calculated by dividing the participants' waist circumference (WC) (cm) by their height (cm).

Physical fitness test

Physical fitness was examined based on common methods of measuring elderly people. MS was evaluated using a grip dynamometer (GRIP-D 5401, Takei, Japan), and the maximum value was recorded in units of 0.1 kg by testing the left and right grip twice. Muscular endurance was measured by sitting and standing in a chair. Flexibility was measured using a left flexometer (FLEXION-D 5403, Takei, Japan). Dynamic equilibrium was measured with a 3m target return. Coordination and gait were additionally evaluated.

Blood pressure test

For blood pressure measurement, the subject was seated in a chair and allowed to rest for at least 5 minutes. The subjects' systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured using a brachial automatic sphygmomanometer (OMRON, HEM-7322, Vietnam).

Sarcopenia prediction criterion

The sarcopenia prediction criterion was measured using the ASM body composition test. Firstly, the skeletal muscle mass (SMM) was divided by the participants' height squared (ASM / Ht^2). Secondly, the SMI% was calculated by ASM divided by weight and multiplied by 100 (SMM / Wt × 100). A CC less than 32 cm was used as criteria for sarcopenia prediction.

Spirometry test

The spirometry test was performed using a spirometer (microlife PF 200, Swiss) to measure forced expiratory volume in one second (FEV_1) and peak expiratory flow (PEF). The results were determined whilst the participant was seated in a chair with a spirometer in their mouth. After drawing a full breath, the participant exhaled as much as possible. We recorded the maximum value by measuring this three times.

Statistical analysis

Social Sciences (SPSS) Ver. 18.0 Statistical Program was used to analyse the data of this paper. Pearson's correlation was used to calculate the mean and standard deviation of the measurement items and to analyse the correlation between measurement items. Logistic regression was used to analyse SLM and SMM reduction, relative risk, and a 95% confidence interval (CI) according to age. Statistical significance levels (a) were set to 05.

Results and Discussion

Correlation between body circumference, body composition, and obesity index

Body circumference measurements are used to predict body composition, and equations can are used to assess all genders and age groups. As a result of verifying the correlation between the body circumference, body composition, and obesity index, body circumference was found to have a positive correlation with all measurement variables. In particular, CC showed a high correlation coefficient with SLM (r = .703), SMM (r = .670), and LBM (r = .692). The correlation with the obesity index was lower than that with other body parts. In other words, the effect of the obesity index on CC was less than that of other body parts [Table 2]. Male obesity is mainly fat distributed in the abdomen and female obesity is mainly fat distributed in the hips and thighs. Thus, CC measurement, which have the least influence on the obesity index, are considered a useful method for predicting physical health.

Table 2: Correlation between body circumference, body composition, and obesity index.

r (p)	Upper arm	Waist	Thigh	Calf
SLM	.573 (<.001)	.485 (<.001)	.623 (<.001)	.703 (<.001)
SMM	.553 (<.001)	.415 (<.001)	.594 (<.001)	.670 (<.001)
LBM	.578 (<.001)	.478 (<.001)	.621 (<.001)	.692 (<.001)
BFM	.635 (<.001)	.723 (<.001)	.559 (<.001)	.512 (<.001)
PBF	.407 (<.001)	.541 (<.001)	.334 (<.001)	.183 (.037)
BMI	.665 (<.001)	.701 (<.001)	.594 (<.001)	.547 (<.001)
WHtR	.360 (<.001)	.815 (<.001)	.218 (.012)	.208 (.017)

Correlation between body circumference and PF

PF is defined as the capacity of an individual to carry out everyday activities and to enjoy active leisure activities without excessive fatigue. PF has been linked to many disease, such as cancer, and higher cardiopulmonary fitness has been related to lower cancer incidences and mortality. Therefore, we analysed the correlation between body circumference and PF in elderly women.

Table 3: Correlation between body circumference and physical fitness.

r (p)	Upper arm	Waist	Thigh	Calf
LGS	.203 (.020)	.055 (.533)	.188 (.031)	.259 (.003)
RGS	.245 (.005)	.061 (.487)	.226 (.010)	.278 (.001)
Muscular endurance	-.047 (.005)	-.296 (.001)	.112 (.202)	.113 (.197)
Flexibility	.055 (.532)	-.167 (.056)	.132 (.132)	.049 (.579)
Dynamic equilibrium	-.010 (.909)	.297 (.001)	-.148 (.093)	-.229 (.009)
Coordination	.024 (.787)	.348 (<.001)	-.049 (.575)	-.089 (.311)

Left grip strength (LGS) was found to have a positive correlation with the upper arm circumference (r = .230), thigh circumference (r = .188), and CC (r = .259). Right grip strength (RGS) was found to have a positive correlation with the upper arm circumference (r = .245), the thigh circumference (r = .226), and CC (r = .278). Muscle endurance had a negative correlation with WC (r =-. 296). Dynamic balance had a positive correlation with WC (r = .297) and a negative correlation with CC (r =-. 229). Coordination had a positive correlation with WC (r = .348). CC showed a higher correlation coefficient with MS (grip strength) than with the circumference of other body parts. It was found that the larger the CC, the faster the dynamic balance record [Table 3].

This paper is related to the results of other studies that examined the correlation between body circumference and physical strength, including thigh circumference. Grip strength, an important health related factor, has been reported to be significantly correlated with CC in both males and females (Amaral et al., 2019). The annual loss of bone mineral density (BMD) has been consistent with grip strength from 50 years, and the loss of BMD was most severe in balance and gait in people aged between 60 - 70 years (Daly et al., 2013). The loss of grip and balance is common in elderly people, and it is important to prevent this as much as possible. This study also shows the correlation between CC, grip strength, and dynamic equilibrium. Therefore, mediation is important for the treatment and prevention of changing PF and CC in elderly women.

Correlation between body circumference, blood pressure, sarcopenia risk, and lung capacity

Changes such as decreased muscle cross-sectional area, loss of lower extremity muscle power, neuromuscular changes, and decreased SLM and MS, are common in elderly people. Spirometry changes can also occur in people from 60 to 102 years of age. The risk factors for decreasing forced vital capacity (FVC) and FEV_1 for women is their gender, age, and the high C-reactive protein (Luoto et al., 2019). Therefore, we analysed the correlations between

body circumference, blood pressure, sarcopenia risk, and lung capacity. SBP was negatively correlated with thigh circumference (r =-. 199) and CC (r = .225). ASM showed a positive correlation with the circumference of the upper arm (r = .546), waist (r = .486), thigh (r = .532), and calf (r = .591). SMI was negatively correlated with the circumference of all body parts except for CC. FEV_1 was positively correlated with thigh circumference (r = .199) and CC (r = .208). PEF was positively correlated with CC (r = .218). As a result, CC had a higher correlation coefficient than the circumferences of other body parts, and there was no correlation between SMI and the obesity index in Table 4.

Muscle dysfunction is known to be caused by the interaction of topical or systemic ingredient, and the important ingredient of these disease has been reported to be the decrease in physical activity for limb muscles and pulmonary hyperinflation for the respiratory muscles (Gea et al., 2015). The CC was inversely correlated with the resting pulse rate of elderly women, which suggests that CC can be used to measure resting pulse rates, which would be useful for preventing cardiovascular disease (Takagi et al., 2013). In turn, CC is a more important mortality predictor than BMI for chronic obstructive pulmonary disease patients (Ho et al., 2016). Recently, in Korea, CC has also been considered to be an indicator of sarcopenia (Kim et al., 2018). In other words, CC is one of the important anthropometric measures that can prevent blood pressure, muscular dystrophy, and lung capacity in elderly women.

Table 4: Correlation between body circumference, blood pressure, sarcopenia risk, and lung capacity

r (p)	Upper arm	Waist	Thigh	Calf
SBP	-.110 (.215)	-.034 (.703)	-.199 (.024)	-.225 (.010)
DBP	-.058 (.511)	.102 (.248)	-.038 (.667)	-.063 (.478)
ASM	.546 (<.001)	.486(<.001)	.532(<.001)	.591(<.001)
SMI	-.325 (<.001)	-.441 (<.001)	-.244 (.005)	-.111 (205)
FEV_1	.152 (.082)	-.073 (.405)	.199 (.023)	.208 (.017)
PEF	.124 (.157)	-.033 (.712)	.114 (.193)	.218 (.012)

Risk of Sarcopenia due to loss of SLM and SMM, and risk of sarcopenia by age group

Although there have been many studies on SLM decrease, bone density decrease, and osteoporosis and fractures caused by ageing, little is known about sarcopenia caused by the loss of SLM. Sarcopenia, as an involuntary loss of skeletal muscle tissue that decreases MS as aging progresses. This means that ageing not only causes a decrease in SLM, but also a decrease in MS or performance. In this study, we analysed the risk of muscular dystrophy by

age group according to a decrease of SLM and SMM. After adjusting the age and BMI of the participants, we analysed the sarcopenia risk according to the decrease of SLM and SMM. When the SLM and SMM decreased below the mean, the risk of sarcopenia was 6.000 times higher [Table 5]. After adjusting the BMI of the participants, we analysed the risk of sarcopenia according to age. The risk of sarcopenia was 15.540 times higher in the age group of 80 or more [Table 6]. In other words, myopathy is greatly affected by muscle mass, skeletal muscle mass, and age, especially in people 80 years or over. However, this study had the following limitations: subjects were recruited at age 65 or older, and the genders of the subjects were analysed separately. Though the older adults may have had accompanying diseases, this study did not take co-morbidity into consideration. Despite these limitations, this paper suggested that CC has a positive role in predicting physical health and exercise function, and the measurement method is simple and inexpensive, which confirms its advantages and usefulness as a measurement tool.

Table 5: Risk of sarcopenia due to loss of soft lean mass and skeletal muscle mass

Variable	B	SE	Wals	p	Exp(B)	95% CI
SLM and SMM	1.792	.838	4.574	.032	6.000	1.161 - 30.992

Table 6: Risk of sarcopenia by age

Variable	B	SE	Wals	p	Exp(B)	95% CI
65-69	-	-	-	-	-	-
70-74	1.340	1.126	1.415	.234	3.820	.420 - 34.741
75-79	2.084	1.141	3.334	.068	8.035	.858 – 75.235
80-84	2.743	1.162	5.571	.018	15.540	1.592 – 151.638

Conclusion

The objective of this paper was to analyse the relationship between health status predictors and the body circumference of elderly women so to determine the usefulness of CC. The conclusion is as follows: firstly, CC showed the highest positive correlation with muscle mass, SMM, and LBM, and the least positive correlation with the obesity index. Secondly, CC had a positive correlation with grip strength and dynamic balance. Thirdly, CC showed a negative correlation with SBP and a static correlation with ASM, FEV_1, and PEF. Fourthly, for those over 80 years of age, the decrease in SLM and SMM was 6 times higher and the risk of sarcopenia was over 15.54 times greater. Based on the above results, CC has the capacity to predict physical health and regulate exercise. The measurement method proposed in this study is simple and inexpensive, which confirms its advantageousness and usefulness as a measurement tool. It is suggested that the application of various simple measurement

methods, which can predict certain diseases including sarcopenia, is a field for further research in the future.

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