

Case Study

Correlation between waist and mid-thigh circumference and cardiovascular fitness in Korean college students: a case study

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Abstract. [Purpose] We investigated whether waist and mid-thigh circumference correlated with cardiovascular fitness (VO₂max) in a selected sample of Korean college students. [Subjects and Methods] The subjects were 41 college students (25 males, 16 females; age, > 19 years) who visited the sports medicine laboratory at the Korea National University of Transportation in Chungju-si, Republic of Korea, to undergo measurements of body composition, cardiovascular fitness, and waist and mid-thigh circumference. [Results] VO₂max did not correlate with waist circumference or mid-thigh circumference in males, whereas VO₂max was negatively correlated with mid-thigh circumference, but not waist circumference, in females. [Conclusion] Mid-thigh circumference was not associated with cardiovascular fitness or waist in male college students. However, it was associated with cardiovascular fitness in female college students. Well-designed studies are needed to investigate this further.

Key words: Cardiovascular fitness, Mid-thigh circumference, Waist circumference

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INTRODUCTION

According to the 2013 Korea National Health and Nutrition Examination Survey, the prevalence of obesity was 37.6% in men and 25.1% in women aged ≥ 19 years in the Republic of Korea¹⁾. This finding indicates that approximately one-third of Koreans are obese and that obesity is becoming a serious public, social, and national health issue in the Republic of Korea.

Obesity, particularly abdominal obesity, is strongly associated with an increased risk of cardiovascular disease, type-2 diabetes, hypertension, hyperglycemia, dyslipidemia, musculoskeletal diseases, genetic diseases, and some cancers^{2, 3)}. Thus, it is important to prevent and treat chronic diseases, such as obesity, because the economic losses from chronic diseases are sufficient to cause social problems^{4, 5)}.

Kim et al.⁶⁾ demonstrated that low thigh muscle mass was closely associated with diabetes and preventing chronic disease. Since that study was published, many others have reported relationships between thigh muscle mass (or fat mass) and clinical predictors, such as the homeostasis model assessment-estimated insulin resistance, triglycerides, and total cholesterol^{7, 8)}.

A high fitness level or regular exercise is related to a low

prevalence of chronic diseases, such as obesity and hypertension^{9–13)}. In addition, low fitness is closely associated with mortality¹⁴⁾.

Many studies have reported that obesity, including abdominal obesity, is related to fitness level as well as chronic disease¹⁰⁾. Thus, in this pilot study, we investigated the relationship between waist circumference and cardiovascular fitness (VO₂max). We also examined the relationship between thigh circumference and cardiovascular fitness (VO₂max), because there is a reported relationship between thigh circumference and chronic disease, and fitness level is related to chronic disease.

SUBJECTS AND METHODS

Subjects

This study included 41 college students (25 males, 16 females; age, > 19 years) who visited the Sports Medicine Laboratory at the Korea National University of Transportation in Chungju-si, Republic of Korea, to undergo measurements of body composition, cardiovascular fitness, and waist and mid-thigh circumference. All participants provided informed consent, and this study conformed to the principles outlined in the Declaration of Helsinki. The study design was approved by the Institutional Review Board at the Korea National University of Transportation (KNUT IRB-15).

The parameters measured included body composition (weight, percent body fat, and basal metabolic rate), cardiovascular fitness (VO₂max), waist circumference, and mid-thigh circumference. The body composition instrument (InBody 720, Biospace, Seoul, Republic of Korea) measured resistance of the arms, trunk, and legs at frequencies of 1, 5,

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Table 1. Subjects' characteristics

Variables	Male (n = 25)	Female (n = 16)	Total (n = 41)
Age (years)	22.6 ± 1.2	19.6 ± 0.5	21.4 ± 1.7
Height (cm)	175.0 ± 4.3	162.2 ± 3.9	170.0 ± 7.5
Weight (kg)	73.2 ± 10.7	59.5 ± 8.1	67.8 ± 11.8
Body mass index (kg/m ²)	23.9 ± 3.1	22.6 ± 2.7	23.4 ± 3.0
Body fat (%)	16.9 ± 5.5	27.9 ± 5.2	21.2 ± 7.6
Basal metabolic rate (kcal)	1,683.9 ± 158.2	1,288.1 ± 85.4	1,529.4 ± 236.6
VO ₂ max (ml/kg/min)	47.7 ± 4.9	38.4 ± 4.3	44.1 ± 6.5
Waist circumference (cm)	85.2 ± 7.3	76.8 ± 6.3	81.9 ± 8.0
Mid-thigh circumference (cm)	59.4 ± 6.2	52.8 ± 4.7	56.5 ± 6.2

Data are shown as the mean ± SD

50, 256, 512, and 1,024 kHz through eight tactile electrodes: two in contact with the palm and thumb of each hand and two in contact with the anterior and posterior aspects of the sole of each foot¹⁵). All participants were prohibited from eating 4 h before, exercising 12 h before, and urinating just before the impedance measurements. The participants were told to wear light clothing and remove all metal items that could interrupt the electronic current during measurements. All methods used to assess body composition followed recommendations in the book *Applied Body Composition Assessment*¹⁶). The body mass index (BMI, kg/m²) of each participant was calculated based on weight, height, and body composition (weight, % body fat, and basal metabolic rate).

Cardiovascular fitness (VO₂max) level was determined by a graded exercise test using a treadmill (Quark Series, P/N: C09073-02-99, Cosmed Cardiopulmonary Diagnostics, Rome, Italy). Maximum oxygen consumption was estimated by gradually increasing exercise intensity, starting from 2.74 km/h at a gradient of 10%. The treadmill incline was increased by 2% at 3-min intervals according to the Bruce protocol¹⁷). Maximum oxygen consumption, VO₂max, was recorded when the respiratory exchange rate was above 1.15, there was plateau despite an increase in exercise intensity, the heart rate was 90% of the predicted heart rate maximum, or the subject needed to stop because of exhaustion.

Waist circumference was measured at the trunk midway between the lower costal margin (bottom of the lowest rib) and the iliac crest (top of the pelvic bone) with the subject standing with his/her feet 25–30 cm apart. Mid-thigh circumference was measured midway down the right leg. The measurement was taken by fitting the tape snugly, without compressing the underlying soft tissue. Circumference was measured to the nearest 0.5 cm; at the end of a normal expiration.

All results are presented as means ± standard deviations. According to the central limit theorem, if the number of participants in each group is < 30, the data are likely to be unreliable and will likely not approximate a normal distribution¹⁸). Thus, we used the nonparametric Spearman's correlation analysis to examine the correlation between waist circumference and VO₂max and between mid-thigh circumference and VO₂max. A p value < 0.05 was considered to indicate statistical significance. All analyses were performed using the PASW Statistics software (ver. 18.0; SPSS Inc.,

Table 2. Results of Spearman's correlation analysis for associations between waist and mid-thigh circumference and VO₂max

Variables	VO ₂ max (ml/kg/min)	
	Male (n = 25)	Female (n = 16)
	r	r
Waist circumference (cm)	0.237	-0.185
Mid-thigh circumference (cm)	0.189	-0.572*

*p < 0.05, as determined by Spearman's correlation analysis

Chicago, IL, USA).

RESULTS

The subjects' characteristics are shown in Table 1. The mean age of the males (n = 25) was 22.6±1.2 years, and that of the females (n = 16) was 19.6±0.5 years. The mean height of the males was 175.0±4.3 cm, and that of the females was 162.2±3.9 cm. The mean weight of the males was 73.2±10.7 kg, and that of the females was 59.5±8.1 kg. The mean BMI of the males was 23.9±3.1 kg/m², and that of the females was 22.6±2.7 kg/m². The mean percent body fat of the males was 16.9±5.5%, and that of the females was 27.9±5.2%. The mean basal metabolic rate of the males was 1,683.9±158.2 kcal, and that of the females was 1,288.1±85.4 kcal. The mean VO₂max of the males was 47.7±4.9 mL·kg⁻¹·min⁻¹, and that of the females was 38.4±4.3 mL·kg⁻¹·min⁻¹. The mean waist circumference of the males was 85.2±7.3 cm, and that of the females was 76.8±6.3 cm. The mean mid-thigh circumference of the males was 59.4±6.2 cm, and that of the females was 52.8±4.7 cm.

The results of Spearman's correlation analysis for associations between waist circumference and VO₂max and between mid-thigh circumference and VO₂max are shown in Table 2. VO₂max in males did not correlate with waist circumference (r = 0.237, p = 0.254) or mid-thigh circumference (r = 0.189, p = 0.367). VO₂max in females did not correlate with waist circumference (r = -0.185, p = 0.492), but it did correlate negatively with mid-thigh circumference (r = -0.572, p = 0.021).

DISCUSSION

The purpose of this study was to examine the relationships between waist and mid-thigh circumference and cardiovascular fitness in Korean college students. The results show that cardiovascular fitness was only associated with thigh circumference in female students.

Many studies have reported that a large waist circumference and obesity are related to low fitness levels^{10, 14}. However, this trend is prevalent in obese and elderly subjects due to aging. This finding suggests that a large waist circumference is related to low fitness levels in subjects in poor physical condition. We found no relationship between waist circumference and fitness level in young college students, indicating that total fat mass, rather than waist circumference, is related to fitness level.

Moreover, previous studies have demonstrated that low thigh muscle mass is related to chronic disease in obese subjects⁶⁻⁸. Nevertheless, we found no relationship between thigh circumference and fitness level in male college students with a relatively high fitness level. Interestingly, a small thigh circumference was correlated with a high fitness level in the female students, suggesting that a large thigh circumference in female college students reflects fat mass rather than muscle mass. Thus, a large thigh circumference may be related to a high fat mass, resulting in a low fitness level. Various authors have suggested that VO_2max is associated with the incidence of lifestyle-related diseases^{19, 20}, all-cause mortality²¹⁻²⁵, and continued ability to perform aerobic activity²⁶; thus, it is important to maintain a healthy physical condition to improve fitness. Well-designed studies are necessary to study these factors.

This study had some limitations. Because the participants were recruited from one university in Chungju-si, Republic of Korea, they do not represent all Korean college students. Furthermore, we only evaluated a small number of students ($n = 41$); thus, the results may be unreliable. Moreover, because mid-thigh circumference is not completely representative of the level of thigh muscle mass (or fat mass), it lacks validation. Nevertheless, the major strength of this study was that it focused on determining if waist or mid-thigh circumference was correlated with cardiovascular fitness, which was investigated waist and mid-thigh circumference and cardiovascular fitness, which were investigated for the first time in Korea in this pilot study.

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