J. Phys. Ther. Sci.
27: 3141–3146, 2015

Original Article

# The relationship between distribution of body fat mass and carotid artery intima-media thickness in Korean older adults

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**Abstract.** [Purpose] The aim of this study was to examine the relationships between the amount and distribution of body fat and the carotid intima-media thickness to explore whether coronary artery disease risk may be mediated through effects on the amount of fat mass in older adults. [Subjects and Methods] A total of 200 elderly females was participated. The percentage of body fat mass was measured by the bioelectrical impedance analysis method, and the carotid intima-media thickness was measured by B-mode ultrasound. Analysis of covariance was performed to assess independent associations between the four categories of percentage of body fat mass and the carotid intima-media thickness after multivariate adjustment. Logistic regression analyses were utilized to calculate odds ratios and 95% confidence intervals for examining independent associations between percentage of body fat mass and the estimated risk of coronary artery disease. [Results] Analysis of covariance showed that the carotid intima-media thickness was significantly thick in both obesity and overweight groups. When multivariate-adjusted OR for the estimated risk of coronary artery disease, the odds ratios for the obesity and overweight groups were 3.0 (95% confidence interval, 1.1 to 8.7) and 2.5 (95% confidence interval, 1.0 to 6.1), respectively. [Conclusion] This study demonstrates that elderly females with a high body fat mass are more likely to have the estimated risk of CAD than who fit body fat mass in elderly female.

**Key words:** CAD, Body fat mass, Carotid-media thickness

*(This article was submitted Jun. 5, 2015, and was accepted Jul. 10, 2015)*

## INTRODUCTION

Carotid artery intima-media thickness (CIMT) has been proposed as a surrogate marker of coronary artery disease (CAD)[1)], stroke and myocardial infarction (MI)[2, 3)], vascular event (VE)[4)], and all-cause mortality[5)]; therefore, it is important to prevent of increases in CIMT in healthy adults and the elderly.

It has been reported that increase of CIMT is affected by several factors such as aging[6)], hyperlipidemia[7)], hypertension[8)], metabolic syndrome, type 2 diabetes mellitus[9)], and decreased physical function[10)]. Body mass index (BMI) is widely used as an index of fatness[11)], and the consensus is that it is associated with an increase in CIMT[12–14)], but individual responses are quite variable. Although BMI is an indirect measure of adiposity compared with more direct approaches such as bioelectrical impedance[15, 16)] and does not account for the wide variation in body fat distribution, high BMI is related to increase of the CIMT. Meanwhile, a few studies have reported that body fat mass is a stronger risk factor of CAD in women[17)], and body fat mass (BFM) percentage by bioelectrical impedance analysis (BIA) has been reported to be more associated with high CAD than BMI criteria[18, 19)]. In addition, Chang et al. [20)] reported that Taiwanese adults had a relatively lower BMI but a higher BFM percentage than Caucasians. Also, Calling et al. [17)] reported that BFM percentage is a risk factor for coronary events (CEs), ischemic stroke, and CAD mortality, and they proved that BFM percentage is a stronger CAD risk factor in women than in men. Thus, BFM may be more important than BMI criteria in assessment of obesity in Asian populations. However, to date, there is in sufficient evidence regarding the relationship between CIMT and BFM in Asian populations.

Therefore, we aimed to examine the association between BFM and CIMT community-dwelling older women and to identify the interrelation between the level of body fat mass percent and CIMT.

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## SUBJECTS AND METHODS

A total of 250 people living in Busan, South Korea, participated in this study, all of whom voluntarily submitted applications to participate after seeing our advertisement. However, we excluded 22 people who were performing regular exercise 3 days or more a week; 18 people taking medicines after being diagnosed with heart disease (n = 2), hypertension (n = 5), diabetes (n = 4), osteoporosis (n = 3), or arthritis (n = 4) by a medical specialist; and 10 smokers. Ultimately, 200 people with an average age of 71.2 ± 4.4 years participated in this study. The study was performed in accordance with the guidelines of the Declaration of Helsinki, and written informed consent was obtained from all subjects in accordance with the requirements of the ethics committee of Dong-A University.

After measuring the subjects' heights and body mass, their body fat-free mass (BFFM) and body fat mass (BFM) percentages were measured, respectively, by the bioelectrical impedance analysis method using a body composition analyzer (InBody 720, Biospace, Seoul, South Korea). Waist circumference was measured as the smallest horizontal girth between the costal margin and the iliac crests, and hip circumference was measured at the widest point over the buttocks in a standing position.

From two days before measuring body composition, the subjects were asked to not engage in physical activities other than from the activities they usually do and to refrain from drinking and eating too much. Body composition was measured between 9:00 and 10:00 a.m. when the subjects' stomachs were empty. BMI and waist to hip ratio (WHR) were calculated with their respective formulas. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a mercury sphygmomanometer (HICO, Tokyo, Japan) after the subjects rested for ten minutes.

Physical activity was measured using the Korean short version of the international physical activity questionnaire (IPAQ). The IPAQ is available from https://sites.google.com/site/theipaq/. The short version consists of nine items about time spent during the last 7 days performing vigorous activities (days per week and duration) such as jogging, aerobic dance, cycling, and heavy lifting; performing moderate activities (days per week and duration) such as light lifting and doubles tennis; and walking (days per week and duration). For each type of activity, the weighted metabolic equivalent (MET) minutes per week were calculated as follows: 1) vigorous MET min/week = 8.0 × vigorous intensity activity minutes × vigorous intensity days, 2) moderate MET min/week = 4.0 × moderate intensity activity minutes × moderate intensity days, 3) walking MET min/week = 3.3 × walking minutes × walking days.

CIMT was measured using B-mode ultrasound and a 10-MHz probe (LOGIQ 3, GE Healthcare, Wauwatosa, WI, USA). During measurement of the carotid arteries, the subjects lay on their backs in a dark room, turned their heads 45 degrees, and fully exposed the carotid arteries after they relaxed for minimum 10 minutes; left carotid artery was then measured by ultrasound[21, 22]. Three IMT measurements of diastolic images on each side at 10 mm before or after the carotid bifurcation were obtained. The mean IMT was calculated for each point, and the highest value (maximum IMT) was recorded for each subject and defined as the distance from the lumen-intima interface to the intima-adventitia interface[9]. The carotid artery lumen diameter (CLD) at diastole was measured by M-mode ultrasound. The lumen diameter between the near and far wall intima-media interfaces was imaged along the vessel length, the 10 mm segment proximal to the dilation of the carotid bulb on both sides[23].

Five milliliters of blood was collected from an antecubital vein of all subjects after they fasted for 12 hours, and then the total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) levels were analyzed using an automatic chemical analyzer (Hitachi-7600-110/7170 analyzer, Tokyo, Japan).

The World Health Organization[24] and Dee et al.[25] reported that a BFM percentage over 35% was obesity criterion for women. Therefore, according to the criterion for classification of BFM percentages in Koreans, the subjects were divided into the following four groups: obesity group (OG, > 35.0%), overweight group (OWG, 30.0–35.0%), normal weight group (NWG, 25.0–29.9), and optimal weight group (OPWG, < 20.0–24.9).

Analysis of variance (ANOVA) was used to examine for differences in demographic, blood pressure, physical activity, serum lipid, and carotid artery variables between the four BFM percentage groups. The relationships between BMI and BFM percentages were examined using Pearson's correlation analyses. Since a few studies reported that CIMT is influenced by age, blood pressure, physical activity and serum lipid level[9, 10, 26], our partial correlation, regression analyses, and analyses of covariance (ANCOVA) were adjusted for these variables. Height was also adjusted for since height was significantly different between groups in the present study. Partial correlation and regression analyses were used to assess independent associations between BFM percentages and CIMT after adjustment for age, height, systolic blood pressure, physical activity and total cholesterol. ANCOVA was used to assess independent associations between the four groups of BFM percentages and CIMT after adjustment for age, height, systolic blood pressure, physical activity, and total cholesterol.

CIMT (cutoff value of 0.75 mm reported by Holaj et al. [27], and Touboul et al. [28]) is considered to be a marker of generalized atherosclerosis. The estimated risk of sustaining atherosclerosis was defined as an IMT cut-off over 0.75 mm. Logistic regression analysis was used to calculate the odds ratio (OR) and 95% confidence intervals (CI) for the assessment of CAD risk due to the increase in BFM percentage adjusted for sex, age, height, systolic blood pressure, physical activity, and total cholesterol. Package for the Social Sciences (SPSS) ver. 17.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis, and the measurement results are presented as averages, variations, and standard errors. The statistical level of significance was less than $p<0.05$.

## RESULTS

Table 1 shows the differences in body composition, blood pressure, physical activity, serum lipids, CIMT, and CLD

**Table 1.** The anthropometric characteristics, blood pressure, physical activity, serum lipid and carotid intima-media thickness of subjects

| Variables | Total (n= 200) | Groups | | | | |
|---|---|---|---|---|---|---|
| | | OG (n= 37) | OWG (n= 56) | NWG (n= 61) | OPWG (n= 46) | Post hoc |
| Age (years) | 71.2±4.4 | 70.8±4.1 | 71.3±4.6 | 70.8±4.6 | 72.0±4.2 | NS |
| Height (m) | 1.56±0.06 | 1.54±0.5 | 1.54±0.6 | 1.56±0.06 | 1.57±0.06 | OG<OPWG |
| Body mass (kg) | 58.7±5.8 | 63.4±5.3 | 59.6±5.5 | 57.0±5.4 | 56.1±4.9 | OG>OWG>NWG,OPWG |
| Body mass index (kg/m$^2$) | 24.3±2.4 | 27.0±2.1 | 24.9±1.5 | 23.4±2.1 | 22.7±1.6 | OG>OWG>NWG,OPWG |
| Body fat free mass (kg) | 41.3±4.4 | 39.7±3.4 | 40.7±4.9 | 41.2±4.1 | 43.8±4.2 | OG, OWG<OPWG |
| Body fat mass (kg) | 17.5±4.7 | 23.7±2.4 | 19.4±2.2 | 15.8±1.9 | 12.4±1.1 | OG>OWG>NWG>OPWG |
| Body fat mass percentage (%) | 29.5±5.5 | 37.2±1.6 | 32.5±1.3 | 27.7±2.2 | 22.1±1.4 | OG>OWG>NWG>OPWG |
| Waist to hip ratio | 0.88±0.06 | 0.92±0.05 | 0.89±0.03 | 0.85±0.04 | 0.83±0.03 | OG>OWG>NWG,OPWG |
| Systolic blood pressure (mmHg) | 128.1±7.9 | 132.6±8.7 | 130.3±6.8 | 126.1±7.4 | 124.4±6.5 | OG,OWG>NWG,OPWG |
| Diastolic blood pressure (mmHg) | 74.1±5.5 | 76.5±5.4 | 75.6±4.3 | 72.7±5.8 | 72.1±5.2 | OG,OWG>NWG,OPWG |
| Total METs of physical active (min/week) | 2393±1930 | 1371±3330 | 1688±3025 | 2110±2950 | 2405±2100 | OG<OPWG |
| Total cholesterol (mg/dl) | 195.2±12.4 | 204.1±12.7 | 198.3±11.5 | 192.3±10.3 | 188.2±10.8 | OG,OWG>NWG,OPWG |
| Triglycerid (mg/dl) | 141.4±14.4 | 146.5±19.1 | 142.5±15.5 | 140.9±10.4 | 136.6±11.7 | OG>OPWG |
| Low-density lipoprotein cholesterol (mg/dl) | 120.5±10.6 | 124.2±9.7 | 122.7±9.2 | 119.2±10.4 | 116.5±12.0 | OG>OPWG |
| High-density lipoprotein cholesterol (mg/dl) | 50.4±10.4 | 46.8±8.6 | 49.3±9.1 | 51.3±10.9 | 53.2±10.3 | OG<OPWG |
| Carotid artery intima-media thickness (mm) | 0.73±0.09 | 0.81±0.08 | 0.76±0.08 | 0.70±0.07 | 0.66±0.09 | OG>OWG>NWG>OPWG |
| Carotid artery luminal diameter (cm) | 0.61±0.04 | 0.62±0.03 | 0.61±0.04 | 0.60±0.04 | 0.59±0.04 | OG, OWG>OPWG |

Values are means ± SD.
Groups based on body fat mass percentage: OG, obesity group (>35.0%); OWG, overweight group (30.0–35.0%); NWG, normal weight group (25.0–29.9%); OPWG, optimal weight group (20.0–24.9%)

among the four groups. The results show that the BFM and BFM percentages of the four groups were each significantly different. Body mass, BMI, and WHR were significantly higher in OG than in the other groups, and those of OWG were significantly higher than those of NWG and OPWG. SBP and DBP were significantly higher in OG and OWG than in NWG and OPWG, and height and physical activity were significantly lower in OG than in OPWG; also, BFFM was significantly higher in OPWG than in OG and OWG. Total cholesterol was significantly higher in OG and OWG than in NWG and OPWG, triglycerides and low-density lipoprotein cholesterol were significantly higher in OG than in OPWG, and high-density lipoprotein cholesterol was significantly higher in OPWG than in OG. The CIMTs of the four groups were all significantly different, CLD was significantly greater in OG and OWG than in OPWG.

Table 2 shows the results of logistic regression. Logistic regression analyses were adjusted for age, height, systolic blood pressure, physical activity, and total cholesterol, and the results showed that the risk of CAD was related to the BFM percentage. The OR was 4.044 (CI: 1.581–10.348) for OPWG, 2.800 (CI: 1.251–6.268) for OWG, and 1.877 (CI: 0.398–1.933) for NWG when not adjusted and OPWG was set as the reference, and it was 3.432 (CI: 1.286–9.157) for OG, 2.496 (CI: 1.072–5.813) for OWG, and 1.798 (CI: 0.430–2.225) for NWG when age, height, and blood pressure were adjusted. When age, height, systolic blood pressure, physical activity, and total cholesterol were adjusted, the OR was 3.033 (CI: 1.064–8.650) for OG, 2.459 (CI: 0.998–6.059) for OWG, and 1.684 (0.469–0.828) for NWG.

## DISCUSSION

This study shows that the BFM percentage is positively related to CIMT and that individuals with a high BFM percentage have thicker CIMT than those with a low BFM percentage. It also shows that individuals with a high BFM percentage are more likely to run the risk of their increased CIMT than those with a low BFM percentage.

The recent report on the increase of CIMT that is quoted as omen for CAD, stroke demonstrates that the increase of CIMT is closely related to body composition. General obesity was assessed by BMI, waist circumference, and WHR. A number of previous studies have demonstrated the relationship between obesity and carotid atherosclerosis. Lo et al.[29] divided 99 healthy women (aged 24–59) into BMI >25 kg/m$^2$, 25–30 kg/m$^2$, and >30 kg/m$^2$ groups respectively, and compared their CIMTs and found that CIMT was significantly thicker in the group with a BM >30 kg/m$^2$. Marini et al.[30] compared the CIMTs of 153 women aged 19–48, 73 of which were normal (<27 kg/m$^2$) and 80 of which were overweight (>30 kg/m$^2$), and reported that CIMT was significantly thicker in overweight women. Also, Hassinen et al.[31] studied the relationship between waist circumference, hip circumference, and CIMT in 102 women aged 60–70 and reported that of the CIMT of the women with a waist circumference ≤83 cm and hip circumference ≤98 cm was the least thick and that the CIMT of those with a waist circumference of >83 cm and hip circumference >98 cm was the thickest. These findings show that high BMI, waist circumference, and WHR values are related to the increase in CIMT.

**Table 2.** Odds ratios (ORs) with 95% confidence intervals (CIs) for the cutoff point of carotid artery intima-media thickness and the four groups based on body fat mass percentage

| Categories | Age (yr) | N (%) | Odds ratio (95% CI) | |
|---|---|---|---|---|
| CIMT cutoff point of 0.75 mm | | | | |
| Unadjusted adjusted | | 200 | | |
| Obesity group | 69.9±5.5 | 37 (18.5) | 4.044 | 1.581–10.348 |
| Overweight group | 68.9±7.2 | 56 (28.0) | 2.800 | 1.251–6.268 |
| Normal weight group | 69.7±6.3 | 61 (30.5) | 1.877 | 0.398–1.933 |
| Optirmal weight group | 70.9±5.7 | 46 (23.0) | 1.000 | |
| Adjusted of age and systolic blood pressure | | | | |
| Obesity group | | | 3.432 | 1.286–9.157 |
| Overweight group | | | 2.496 | 1.072–5.813 |
| Normal weight group | | | 1.798 | 0.430–2.225 |
| Optirmal weight group | | | 1.000 | |
| Adjusted for multiple factors | | | | |
| Obesity group | | | 3.033 | 1.064–8.650 |
| Overweight group | | | 2.459 | 0.998–6.059 |
| Normal weight group | | | 1.684 | 0.469–2.828 |
| Optirmal weight group | | | 1.000 | |

CIMT: carotid intima-media thickness; CI: confidence interval
Groups based on body fat mass percentage: OG, obesity group (>35.0%); OWG, overweight group (30.0–35.0%); NWG, normal weight group (25.0–29.9%); OPWG, optimal weight group (20.0–24.9%)
Adjusted for multiple factors: adjusted for age, height, systolic blood pressure, physical activity level, and total cholesterol level

However, despite the association of BMI and WHR with CIMT, BMI has various deficiencies as a measure of adiposity and is an indirect measure of body fat compared with more direct approaches such as bioelectrical impedance, and BFM is an imprecise measurement of fatness compared with bioelectrical impedance[20, 32]. In addition, a high BFM is associated with a high risk of metabolic disorders, CVD[33], and CAD[18]. Furthermore, a few studies reported that evaluation of obesity based on the BFM percentage is much more desirable than evaluation with BMI criteria in Asians (Chinese, Japanese, Korean, Taiwanese, and Filipinos)[20, 34]. Also, Saito et al.[19] and Zeng et al.[35] reported that obesity based on increased BFM has a closer association with the risk of CVD than BMI in Japanese and Chinese. We believe that evaluation of body composition by BFM provides more accurate information concerning obesity than BMI and WHR, and a high BFM percentage may be more associated with early progress of CAD and CVD in Asians than BMI and WHR. However, the relationship between the distribution of BFM percentage and CIMT remains unclear.

Therefore, after classifying the subjects into four groups according to BFM percentage we compared the differences in CIMT and CLD. Our study shows that BMI and WHR were significantly different in OG compared with the other groups and that they were significantly different in OWG compared with NWG and OPWG. On the other hand, there was no difference in BMI and WHR between NWG and OPWG. However, the BFM percentage was significantly different among the four groups in our subjects. Our results suggest that the assessment of obesity by BMI, WHR, and the BFM percentage produces different results and that the BFM percentage may be more valid than the BMI or WHR in obesity assessment for Asian population. Also, there were significant differences in the increase in CIMT among all the groups.

We examined the independent relation between CIMT and body composition after adjustment for age, height, blood pressure, physical activity, and total cholesterol. Partial correlation analysis of BFM percentage, BMI with CIMT has a significant positive linear relationship (r = 0.475, r = 0.344, r = 0.326, p<0.001, respectively). This research also showed that there was a higher association between CIMT and BFM percentage compared with other body composition factors, such as BMI and WHR. Furthermore, even if we adjusted for the covariance of age, height, blood pressure, physical activity, and total cholesterol level, research must be carried out to ascertain if there is an independent difference in CIMT based on the BFM percentage. In our ANCOVA models, the CIMTs of the four groups classified by BFM percentage showed significant differences (F-value 10.871, p<0.001) between groups after adjustment for age, height, systolic blood pressure, physical activity, and total cholesterol, revealing that the CIMT and BFM percentage are mutually related. Therefore, our research indicates that CIMT is related to BMI, WHR, and the BFM percentage in elderly women. Our study results also suggest that the BFM percentage may have a stronger relationship with CIMT than the BMI and WHR.

Tounian et al. [36] studied 48 overweight children and 27 normal children with in average age of 12 and reported that the CIMT of overweight children was 0.49 mm and that of normal children was 0.50 mm, showing no big difference between the two groups. Furthermore, Olson et al. [37] divided 59 women in their thirties with normal menstruation into a normal weight group (18.5–24.9 kg/m$^2$), overweight group (25.0–29.9 kg/m$^2$), and obese group (≥30 kg/m$^2$) by BMI and reported that the BFM percentage showed a significant difference between the groups, with the values being 33.4%, 43.0%, and 45.9%, respectively; however, the carotid artery IMT showed no difference between the groups, with the values being 0.38 mm, 0.47 mm, and 0.45 mm, respectively. These results mean that the relationship between the increase in CIMT and the BFM percentage can be different according to age. Also, it is likely that the high BFM percentages are more closely related to increases in CIMT than high BMIs or WHRs in elderly women.

Holaj et al.[27] reported that the CIMT cutoff value for detection of significant CAD is 0.75 mm (sensitivity 78%, specificity 79%, positive predictive value 95%, negative predictive value 41%, odds ratio 12.9, CI 3.5 to 47.6). CIMT (cutoff value of 0.75 mm reported by Holaj et al.[27], and Touboul et al.[28]) is considered to be a marker of generalized atherosclerosis. The estimated risk of sustaining atherosclerosis was defined as an CIMT cut-off over 0.75 mm.

When percentage body fat data were categorized into quartiles, the multifactor-adjusted odds ratio and 95% CI as calculated by logistic regression analysis showed significant relationships between the estimated vulnerability to the estimated risk of CAD and the body fat distribution in elderly women. Our logistic regressions confirmed significant relationships between the BFM percentage and risk of CAD estimated by a CIMT cutoff of 0.75 mm. In a crude model, the estimated risks of CAD in obesity and overweight groups were 4.0 (95% CI, 1.6 to 10.3) and 2.8 (95% CI, 1.3 to 6.3) times higher than that for individuals in the optimal weight group (reference). When adjusted for age, height, and systolic blood pressure, the estimated risks of CAD in obesity and overweight groups were 3.4 (95% CI, 1.3 to 9.2) and 2.5 (95% CI, 1.1 to 5.8) times higher than that for individuals in the optimal weight group (reference). When adjusted for age, height, systolic blood pressure, physical activity, and total cholesterol, the risk estimated risk of CAD in obesity and overweight groups were 3.0 (95% CI, 1.1 to 8.7) and 2.5 (95% CI, 1.0 to 6.1) times higher than that for individuals in the optimal weight group (reference). Thus, these results suggested that high BFM percentage are closely associated with a high risk of CAD due to increased CIMT (> 0.75 mm) in elderly women.

Research carried out by Meeuwsen et al.[38] targeting 23,627 British individuals reported that the relationship between BMI and body fat percentage is not so strong. Also, a recent study carried out by Marques-Vidal et al.[18] targeting more than 5,000 Swiss Caucasian males (average age of 51.7) and females (average age of 53.1) asserts that body fat percentage is more closely related to coronary artery disease than BMI, waist circumference, and WHR. These results imply that there is a possibility that the connection between BFM percentage and CIMT does not only pertain to Asians but pertains to Europeans as well.

On the other hand, it is reported that a low fat-free mass (FFM) is related to increase of the prevalence rate of chronic obstructive pulmonary disease (COPD)[39] and disability[40, 41] and closely related to increase of morbidity and mortality[42]. This study found out that the FFM was lowest in the obesity group, which had the highest BFM percentage, followed by the overweight group, which had the next lowest FFM, and that the optimal weight group, which had the lowest BFM percentage, had the highest FFM. These results suggested that a low FFM can be related to a high CIMT. However, it is necessary for more concrete research on this to be carried out.

This research targeted elderly women distinctively and indicates a connection between body fat percentage and CIMT; nonetheless, the number of research subjects was low, and there may be a limit of performing a cross study.

In conclusion, this research revealed that increased body fat percentage is independently connected to increased intima-media thickness in elderly Asian women. Additionally, the connection between obesity based on a high body fat percentage (>35%) and the CAD risk resulting from the carotid intima-media thickness was proven. Our results will serve as important information concerning the importance of body fat management in prevention of coronary artery disease resulting from the carotid intima-media thickness.

## ACKNOWLEDGEMENT

The study was supported by the Dong-A University Research fund.

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