INFLUENCE OF HEIGHT AND AGE ON WAIST CIRCUMFERENCE IN JAPANESE OUTPATIENTS WITH CORONARY RISK FACTORS

SHIGENORI ITO, MD, TAKAFUMI KATO, MD*, TAKAYUKI YOSHIDA, MD, TOSHIKI INAGAKI*, MD, AND KOICHI SATO, MD
Division of Cardiology, East Medical Center Higashi Municipal Hospital City of Nagoya, Nagoya, Japan
*Division of Cardiology, East Medical Center Moriyama Municipal Hospital City of Nagoya, Nagoya, Japan
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ABSTRACT

Waist circumference might be influenced by anthropomorphic factors other than factors that increase visceral fat accumulation. We investigated the influence of height and age on waist circumference in 409 consecutive outpatients referred to our clinic. Height, body weight, and waist circumference measurements and blood sampling were performed during fasting in the morning. The correlation between waist circumference and age and height were evaluated. There was a weak inverse correlation between age and waist circumference in overall patients (R = -0.181, p = 0.0002). The correlation was found only in males (R = -0.326, p < 0.0001). A weak correlation was also present between height and waist circumference (R = 0.154, p = 0.0001). This correlation was stronger in males (R = 0.354, p < 0.0001) than in females (R = 0.201, p = 0.0029). The relation between height and waist circumference did not exist in the smaller body mass index (BMI; < 18.50) group. However, there was a slight correlation in the normal BMI group (R = 0.120, p = 0.057) and a significant correlation in the large BMI (≥ 25) group (R = 0.245, p = 0.008). We conclude waist circumference in Japanese patients was affected by age and height. Some attention should be warranted when deciding on a cutoff point for waist circumference in the criteria of metabolic syndrome.

Key words: metabolic syndrome, waist circumference, age, height, coronary risk factors

伊藤重範，加藤孝記，吉田孝幸，稲垣俊明，佐藤孝一
Corresponding author: Shigenori Ito, MD
Division of Cardiology, East Medical Center Higashi Municipal Hospital City of Nagoya, 1-2-23, Wakamizu-cho, Chikusa-ku, Nagoya-shi, Aichi-ken, 464-8547, Japan
phone: 81-52-721-7171, fax: 81-52-721-1038, e-mail: sito@higashi-hosp.jp.
INTRODUCTION

The reinforced criteria published by 8 Japanese medical societies and the International Society of Diabetes Mellitus include waist circumference as an essential factor with which to diagnose metabolic syndrome. In the Japanese criteria, it is the primary factor. However, in contrast to its importance in these criteria, physical status and anthropometric status have not been fully taken into consideration.

Waist circumference might be partially influenced by physical status or anthropomorphic factors, in addition to risk factors that increase visceral fat accumulation. Thus, physical status may affect the diagnosis of metabolic syndrome, leading to the over- or underestimation of metabolic syndrome in some patients.

In this study, we investigated the influence of height as a physical element and age as a biological factor on waist circumference in outpatients referred to our cardiovascular division.

METHODS

The study population consisted of 409 consecutive outpatients who were referred to the cardiologist (Shigenori Ito) at Moriyama Municipal Hospital between August 1, 2005 and October 31, 2005. Height, body weight, and waist circumference measurements and blood sampling were performed at an outpatient clinic during fasting in the morning. The measurement of waist circumference was conducted according to the guideline of the Japanese Society of the Study of Obesity. Briefly, waist circumference was measured at the level of the navel with the patient standing and slight expiration.

Hypertension was defined as a diastolic blood pressure of $\geq 90$ mmHg, systolic blood pressure of $\geq 140$ mmHg, or current medication for hypertension (as defined by WHO 1999). Diabetes mellitus was diagnosed according to the criteria defined by the National Diabetes Data Group and World Health Organization. Dyslipidemia was diagnosed when total cholesterol was $\geq 220$ mg/dL, triglycerides $\geq 150$ mg/dL, HDL cholesterol $< 40$ mg/dL, or if the patient was taking any drug for dyslipidemia. Hyperuricemia was diagnosed when the uric acid level was $\geq 7.0$ mg/dL or the patient was taking a medication. Previous cardiovascular disease was defined as a past history of coronary heart disease (CHD) and/or cerebral infarction. A diagnosis of CHD was validated by coronary angiography in all cases.

The correlation between waist circumference and age and height were evaluated in the total patient population and in subgroups stratified by sex and height. The subjects were divided into two age groups; 75 years of age or older (age $\geq 75$ group) and less than 75 years of age (age $< 75$ group). The patients were also divided into 4 groups according to height (cm); less than 150, 150 $\leq$ height $< 160, 160 \leq$ height $< 170,$ and $170 \leq$.

Furthermore, the patients were also divided into 4 groups according to height (cm); $< 162$ and $\geq 162$ in male, $< 150$ and $\geq 150$ in female and age (years); $< 75$ and $\geq 75$ in both male and fe-
male to evaluate the influence of height and age on waist circumference and the incidence of metabolic syndrome coincidentally.

Statistical analysis
Data are expressed as mean±SD for continuous values and as frequencies for categorical variables. Comparison of continuous data between the two groups were performed with the non-paired Student t test. Comparison of continuous data among the four groups were performed with one-way ANOVA followed by Fisher PLSD post hoc test. Distribution difference of clinical variables and incidence of metabolic syndrome and multiple risk factors were assessed by the chi-square test. Correlations were analyzed using univariate linear regression analysis. p < 0.05 was considered statistically significant. Statistical analysis was performed with Statview 5.0 (SAS Institute, Cary, North Carolina).

RESULTS
The baseline clinical characteristics are shown in Tables 1 and 2. There were gender- or age-related differences in some variables. Hypercholesterolemia was more frequent in females. Hypo high density lipoproteinemia and hyperuricemia were more frequent in males (Table 1). In the age ≥ 75 group, height, body weight, and waist circumference were significantly smaller than in the age < 75 group (Table 2). The incidences of diabetes mellitus and hypercholesterolemia were lower in the age ≥ 75 group compared to the age < 75 group (Table 2). The difference was detected only in males for hypercholesterolemia (15 (20%) vs. 52 (45%), p = 0.001) and only in females for diabetes mellitus (18 (20%) vs. 53 (40%), p = 0.002) by subgroup analysis. Current smoking and alcohol intake were less frequent in the age ≥ 75 group.

There was a weak inverse correlation between age and waist circumference in the total patient population (R = -0.181, p = 0.0002, Fig. 1a). The correlation was found only in males (R = -0.326, p < 0.0001, Fig. 1b), but not in females (Fig. 1c). A weak correlation was also present between height and waist circumference (R = 0.154, p = 0.0001, Fig. 2a). When stratified by sex, this correlation was stronger in males (R = 0.354, p < 0.0001, Fig. 2b) than in females (R = 0.201, p = 0.0029, Fig. 2c). When stratified into 3 groups by BMI, the relation between height and waist circumference did not exist in the smaller BMI group (Fig. 3a). However, there was a slight correlation in the normal BMI group (R = 0.120, p = 0.057, Fig. 3b) and a significant correlation in the large BMI group (R = 0.245, p = 0.008, Fig. 3c).

To conduct a more detailed analysis, we compared waist circumference among male patients in the 4 groups stratified by height into thin (18.5 < BMI), normal (18.5 ≤ BMI < 25), or obese (BMI ≥ 25) patients (Fig. 4). In thin male patients, mean waist circumference was below 85 cm in all groups. In contrast, mean waist circumference was over 85 cm in three groups with BMI ≥ 25. The only exception was one obese patient whose height was < 150 cm. In the normal BMI group, mean
waist circumference differed between the 160-170 cm group and the over 170 cm group (84.0 ± 6.7, n = 57, 88.3 ± 5.0, n = 20, respectively, p = 0.012). The scatter plots of these patients are shown in Fig. 5. In male patients with a normal BMI, the number of risk factors was similar among the groups divided according to height. The ratio of a waist circumference ≥ 85 cm follows: 16/19 (84%) for height ≥ 170 cm, 28/57 (49%) for 160 cm ≤ height < 170 cm, and 10/42 (23%) for height < 160 cm, p < 0.0001. The mean BMI for the groups was 22.3 ± 1.9, 21.8 ± 1.6, 21.8 ± 1.6, respectively (NS). The number of components of metabolic syndrome was also similar among these 3 groups (1.11 ± 1.15, 1.25 ± 0.88, 1.14 ± 0.86, NS). In female patients, waist circumference was similar among all height groups regardless of BMI (Fig. 6). Among the 4 groups stratified by height and age, there was no difference in the incidence of metabolic syndrome and multiple risk factors ≥ 2 irrespective of waist circumference in both male and female (Table 3). In male

<table>
<thead>
<tr>
<th>TABLE 1. Gender Differences in Clinical Characteristics</th>
<th>Overall (N = 409)</th>
<th>Male (N = 189)</th>
<th>Female (N = 220)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>70.3 ± 11.0</td>
<td>69.2 ± 11.2</td>
<td>71.3 ± 10.9</td>
<td>0.052</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>56.0 ± 11.9</td>
<td>61.3 ± 11.4</td>
<td>51.3 ± 10.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>155.6 ± 9.2</td>
<td>162.5 ± 6.4</td>
<td>149.7 ± 6.8</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.0 ± 3.8</td>
<td>23.1 ± 3.6</td>
<td>22.8 ± 3.9</td>
<td>0.403</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>86.5 ± 10.5</td>
<td>85.9 ± 10.6</td>
<td>87.0 ± 10.4</td>
<td>0.291</td>
</tr>
<tr>
<td>Hypertension</td>
<td>279 (68%)</td>
<td>127 (67%)</td>
<td>152 (69%)</td>
<td>0.799</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>125 (30%)</td>
<td>54 (28%)</td>
<td>71 (32%)</td>
<td>0.617</td>
</tr>
<tr>
<td>Hypertriglyceridemia</td>
<td>100 (24%)</td>
<td>49 (25%)</td>
<td>51 (23%)</td>
<td>0.520</td>
</tr>
<tr>
<td>HypoHDL-Cholesterolemia</td>
<td>17 (4%)</td>
<td>13 (6.8%)</td>
<td>4 (1.7%)</td>
<td>0.011</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>194 (47%)</td>
<td>67 (35%)</td>
<td>127 (57%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hyperuricemia</td>
<td>106 (25%)</td>
<td>73 (38%)</td>
<td>33 (15%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current smoking</td>
<td>96 (21%)</td>
<td>77 (44%)</td>
<td>19 (8%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Alcohol</td>
<td>110 (26%)</td>
<td>87 (46%)</td>
<td>23 (10%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Previous CAD</td>
<td>43 (10%)</td>
<td>28 (14%)</td>
<td>15 (6%)</td>
<td>0.008</td>
</tr>
<tr>
<td>Previous CVD</td>
<td>32 (7%)</td>
<td>17 (8%)</td>
<td>15 (6%)</td>
<td>0.396</td>
</tr>
<tr>
<td>Previous CAD and/or CVD</td>
<td>69 (16%)</td>
<td>40 (21%)</td>
<td>29 (13%)</td>
<td>0.028</td>
</tr>
<tr>
<td>On Bezafibrate</td>
<td>14 (3%)</td>
<td>9 (4%)</td>
<td>5 (2%)</td>
<td>0.630</td>
</tr>
<tr>
<td>On Statin</td>
<td>124 (30%)</td>
<td>39 (20%)</td>
<td>85 (38%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>On ACE-I</td>
<td>37 (9%)</td>
<td>21 (5%)</td>
<td>16 (7%)</td>
<td>0.171</td>
</tr>
<tr>
<td>On ARB</td>
<td>127 (31%)</td>
<td>60 (31%)</td>
<td>67 (30%)</td>
<td>0.751</td>
</tr>
<tr>
<td>On OHA</td>
<td>53 (12%)</td>
<td>23 (12%)</td>
<td>30 (13%)</td>
<td>0.675</td>
</tr>
<tr>
<td>On Pioglitazone</td>
<td>15 (3%)</td>
<td>6 (3%)</td>
<td>9 (4%)</td>
<td>0.630</td>
</tr>
</tbody>
</table>

Abbreviations: BMI = body mass index, CAD = coronary artery disease, CVD = cerebrovascular disease, ACE-I = angiotensin-converting enzyme inhibitor, ARB = angiotension II receptor blocker, OHA = oral hypoglycemic agent
patients with multiple risk factors, waist circumference was less in the group 3 with shorter and older patients compared with the group 2 with taller and younger patients (86.6 ± 8.4 and 92.6 ± 10.0, respectively, p = 0.0436) (Table 3).

**DISCUSSION**

The results of the present study indicate that waist circumference in Japanese patients with risk factors for atherosclerosis was affected by age and height. Especially in male subjects with multiple risk factors, the waist circumference was less in shorter and older group than in taller and younger group. For the patients in this subset, there may be some room to relax the criteria for metabolic syndrome.

Although the degree was not great, some attention are warranted when deciding on a cutoff point for waist circumference in the criteria of metabolic syndrome.

Despite recent controversy about the feasibility of the concept of metabolic syndrome2,5, the term
There was a weak inverse correlation between age and waist circumference in the overall patients \( (R = -0.181, p = 0.0002, \text{Fig. 1a}) \). The correlation is found in only males \( (R = -0.326, p < 0.0001, \text{Fig. 1b}) \) and not females \( (\text{Fig. 1c}) \).

A weak correlation was also present between height and waist circumference \( (R = 0.154, p = 0.0001, \text{Fig. 2a}) \). When stratified by sex, this relation was stronger in males \( (R = 0.354, p < 0.0001, \text{Fig. 2b}) \) than in females \( (R = 0.201, p = 0.0029, \text{Fig. 2c}) \).
Fig. 3. Relationship between waist circumference and height according to body mass index

When stratified into 3 groups by BMI, a relation between height and waist circumference did not exist in the smaller BMI group (Fig. 3a). However, there was a slight correlation in the normal BMI group ($R = 0.120, p = 0.057$, Fig. 3b) and a significant correlation in the large BMI group ($R = 0.245, p = 0.008$, Fig. 3c).

Fig. 4. Waist circumference and height stratified by body mass index (males)

In thin male patients, mean waist circumference was below $85 \text{ cm}$ in all groups. In contrast, mean waist circumference was over $85 \text{ cm}$ in all groups, except for one obese patient whose height was $< 150 \text{ cm}$. In the normal BMI group, mean waist circumference differed between the group with a height between 160-170 cm and that with a height over 170 cm.
FIG. 5. Relationship between waist circumference and height in males with a body mass index between 18.5 and 25.0.

In male patients with a normal BMI, the number of risk factors was similar between the 4 groups divided according to height. The ratios of a waist circumference ≥ 85 cm were 16/19 (84%) for height ≥ 170 cm, 28/57 (49%) for 160 ≤ height < 170, and 10/42 (23%) for height < 160 cm, p<0.0001. Open circles indicates the patients with waist circumference ≥ 85 cm and closed circle means those with waist circumference < 85 cm.

FIG. 6. Waist circumference and height stratified by body mass index (females)

In female patients, waist circumference was similar among all height groups regardless of BMI.
metabolic syndrome has become popular among citizens as well as medical personnel. The reinforced criteria published by different Japanese medical societies and the International Society of Diabetes Mellitus include waist circumference as a factor that is essential when diagnosing metabolic syndrome. However, in these criteria, physical status and anthropometric status have not been taken into consideration. In patients with a normal BMI but who are tall (height > 170 cm), height itself may contribute to a waist circumference because of larger bone and nonfat soft tissue mass. On the other hand, for males or older, cm would be too large to make a diagnosis of metabolic syndrome based on the results obtained in this study. In Japanese patients with an average height and body weight, a slight difference in height may be a decisive factor in concluding whether or not they have metabolic syndrome by analyzing our results. Thus, we always need to be aware that a small (a few centimeters) difference in waist circumference may originate from a physical difference, and thus we should consider risk factors other than waist circumference when diagnosing metabolic syndrome.

Height and age have been shown to have limited influence on the difference in waist circumference between Caucasian subjects of difference stature. Without age adjustment, height could explain 0.3-3.5% and 0.1-2.5% variance in waist in men and in women, respectively, and the corresponding variances were 0.4-7.5% in men and 0.0-2.6% in women with age adjustment. In this study, although waist alone may be used to indicate adiposity or to reflect metabolic risk factors, the influence of height on body weight was important.

In middle-aged people and the elderly (60-75 years old), several anthropometric variables such as waist circumference and body mass index increase with age. In contrast, the present results support those of some reports that in elderly subjects more than 75 years old, waist circumference might decrease. Waist circumference and BMI have been reported to decrease in people over 75 years of age.
In two American Heart Association scientific statements, published in collaboration with the Society of Geriatric Cardiology, acute coronary care in the elderly was discussed in terms of non-ST segment-elevation acute coronary syndrome (ACS) and ST-segment-elevation myocardial infarction. According to ACS data sources, body mass index was found to decrease as age advanced (28 ± 5, 27 ± 4, 26 ± 4, 25 ± 4 for < 65 years, 65-74 years, 75-84 years, ≥ 85 years, respectively, in VIGOUR (pooled) trials with 34, 226 patients and 30 ± 8, 29 ± 6, 27 ± 6, 25 ± 5 for < 65 years, 65-74 years, 75-84 years, ≥ 85 years, respectively, in NRMI 2-4 registry with 1,076,796 patients). Similarly, from the ST-segment-elevation myocardial infarction data, body weight (kg) decreased as age increased (81.2 ± 14.1, 76.2 ± 12.8, 71.9 ± 12.1, and 67.6 ± 11.2 kg for < 65 years, 65-74 years, 75-84 years, and ≥ 85 years, respectively, in VIGOUR (pooled) trials with 101,982 patients, and 82.1 ± 17.5, 76.8 ± 15.1, 71.6 ± 14.5, 64.9 ± 14.6 kg for < 65 years, 65-74 years, 75-84 years, and ≥ 85 years, respectively, in the CRUSADE community trials with 56,963 patients). The baseline characteristics of the subjects were not adjusted among the 4 groups in these reports. Thus, in patients with cardiac events, BMI and body weight both decrease as age increases.

In the older population, changes in weight and body composition occur in the absence of disease and are associated with mortality and physical functioning level. Weight loss rather than weight gain appears to be more important in this population and promotion of intervention modification targeted at weight maintenance would be important.

LIMITATIONS

There are several limitations in this study to consider. First of all, this was a single center study with a small sample size, and the results may not be universally applicable. Second, the study was cross-sectional and the prognosis could not be evaluated. Thus, we were unable to determine whether the influence of age and height on waist circumference criteria in metabolic syndrome may or may not lead to some prognosis alteration. Third, we did not measure the fat area by computed tomography. Finally, there are no data in this study indicating what the influence of age and height on waist circumference is based on.

CONCLUSIONS

Waist circumference in patients with risk factors for atherosclerosis was affected by age and height. Some attention might be warranted when deciding on a cutoff point for waist circumference in the criteria of metabolic syndrome.

REFERENCES
