Original Article

Incidence of Hypertension in Individuals with Abdominal Obesity in a Rural Japanese Population: The Tanno and Sobetsu Study

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Although abdominal obesity (AO) assessed by waist circumference (WC) is an important component of the metabolic syndrome (MetS), the usefulness of AO as a predictor of hypertension (HT) is not known. In this study, we investigated the incidence of HT in residents of two rural communities in Japan. The subjects were 187 men and 209 women selected from 712 residents who had undergone medical examinations in the towns of Tanno and Sobetsu, Hokkaido, in 1994 and 2002. Participants with HT in 1994 were excluded. Participants with AO were determined according to the WC criteria in the Japanese definition of MetS (≥85 cm for men, ≥90 cm for women). The participants were divided into two groups: a non-AO group and an AO group. We compared the incidence of HT between the two groups and found a significantly higher incidence in the AO group. The results of logistic regression analysis showed that the relative risk of developing HT in individuals with AO was 2.33 (p=0.017; 95% confidence interval [CI], 1.17–4.63) and that the risk per 1-cm increase in WC from 1994 to 2002 was 1.06 (p=0.003; 95% CI, 1.02–1.10), both adjusted for several confounding factors. The results of this study suggest that, to prevent HT in Japanese, it is important to manage abdominal obesity and to monitor WC in individuals with or without abdominal obesity. (*Hypertens Res* 2008; 31: 1385–1390)

***Key Words*: abdominal obesity, hypertension, waist circumference, metabolic syndrome, community-based survey**

Introduction

In 2005, the Japanese Society of Internal Medicine and eight related scientific societies jointly announced new Japanese diagnostic criteria for the metabolic syndrome (MetS) (*1*). The new criteria include abdominal obesity as defined by waist circumference (WC).

The Ministry of Health, Labour and Welfare started a new program of health examinations in Japan in April 2008 (Health Service Bureau, Ministry of Health, Labour and Welfare: Standard program of medical examination and health guidance (fixed version). http://www.mhlw.go.jp/bunya/kenkou/seikatsu/index.html [accessed February 7, 2008; in Japanese]). This program adopts the Japanese diagnostic criteria for MetS in order to identify individuals at high risk for lifestyle-related and atherosclerotic diseases. Although the WC criterion will also be used to identify high-risk individuals in the new system, the usefulness of the criterion's definition of abdominal obesity as a predictor of hypertension (HT) is not known.

In this study, we investigated the incidence of HT in resi-

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dents of two rural communities in Japan to determine the relationship between HT and abdominal obesity.

Methods

Of the 1,525 residents who were aged 30 years or older when they received medical examinations in the towns of Tanno and Sobetsu, Hokkaido, in 1994, 712 also underwent medical examinations in 2002. We excluded the following individuals from those 712 residents: 14 individuals without data on blood pressure (BP) or WC, 140 individuals who were defined as having HT (systolic BP [SBP]≥140 mmHg and/or diastolic BP [DBP]≥90 mmHg) without medication, 146 individuals who were on medication for HT, and 16 individuals who had received medical treatment for coronary heart disease or cerebral vascular disease. The remaining 396 individuals were participants in this analysis. We received written informed consent from all participants.

WC, body mass index (BMI), SBP, DBP, fasting plasma glucose (FPG), total cholesterol (T.chol), triglyceride (TG), and HDL cholesterol (HDL-C) were measured in each subject. Blood samples were collected early every morning when the subjects felt hungry, at least 10 h after they had last eaten.

Participants with abdominal obesity were determined according to the new Japanese diagnostic criteria for MetS (*1*). Abdominal obesity is defined as WC≥85 cm for men and ≥90 cm for women.

The participants were divided into two groups: an abdominal obesity (AO) group and a non-AO group. The measured items were compared between the groups. We also compared the incidence of HT between the groups for subjects who were newly determined as having HT (subjects with SBP≥140 mmHg and/or DBP≥90 mmHg or subjects who were on medication for HT) on the basis of the 2002 medical examination data. Moreover, we estimated and compared the relative risk of developing HT between the groups.

SPSS Ver.12.0J (SPSS, Chicago, USA) was used for statistical analysis. All numerical values are expressed as means±SD. The unpaired *t*-test and the χ^2 test were used for the examination of intergroup differences and for frequency comparison, respectively. Multiple logistic regression analysis was used to estimate the relative risk of HT. The relative risk was adjusted for age, sex, and high-normal BP (SBP≥130 mmHg and/or DBP≥85 mmHg) in 1994, smoking (yes/no), FPG, and T.chol. In the same model, we assessed the effect of an increase in WC on the development of HT by using ΔWC (=WC [cm] in 2002 − WC [cm] in 1994). The significance level in all analyses was set at $p<0.05$.

This study was approved by the Ethics Committee of Sapporo Medical University.

Results

Table 1 shows the characteristics of the subjects in the non-AO and AO groups in 1994. Age, percentage of men, BMI, SBP, DBP, TC, TG, and FPG were higher in the AO group than in the non-AO group. HDL-C was significantly lower in the AO group than in the non-AO group.

Table 1. Basal Characteristics in the Non-AO Group and the AO Group in 1994

	Non-AO group (n=312)	AO group (n=84)
Age	57.2±9.3	59.5±8.8*
Men/women	112/200	75/9#
BMI (kg/m^2)	22.4±2.3	25.5±3.0*
SBP (mmHg)	121.3±10.5	126.3±9.5*
DBP (mmHg)	73.5±6.9	77.4±6.6*
T.chol (mg/dL)	188.4±30.1	193.8±29.0*
TG (mg/dL)	110.1±68.5	159.8±82.1*
HDL-C (mg/dL)	58.1±13.8	48.6±12.2*
FPG (mg/dL)	92.1±11.7	105.1±27.8*

Age, percentage of men, BMI, SBP, DBP, TC, TG, and FPG were higher in the AO group than in the non-AO group. HDL-C was significantly lower in the AO group than in the non-AO group. *$p<0.05$, unpaired *t*-test, #$p<0.05$ χ^2 test. AO, abdominal obesity; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; T.chol, total cholesterol; TG, triglyceride; HDL-C, HDL cholesterol; FPG, fasting plasma glucose.

In the 1994 data, there are significant positive correlations between WC and SBP and between WC and DBP in both men and women. There are also significant positive correlations between WC in 1994 and SBP in 2002 and between WC in 1994 and DBP in 2002 in both men and women (Fig. 1).

Figure 2 shows the percentage of HT in 2002 in each 1994 WC category. The higher the WC category, the higher the incidence of HT in both men and women. *p* for the trend was significant in both men and women.

The results of 10–11 years of follow-up are shown in Fig. 3. There were 312 individuals in the non-AO group and 84 in the AO group. Of the 312 individuals in the non-AO group, 177 remained in the non-AO category in 2002, but the remaining 79 individuals were changed to the AO category in 2002. Sixty-nine of the 84 individuals in the AO group remained in the AO category in 2002, but the remaining 15 individuals changed to the non-AO category. We divided the participants into these four groups (non-AO to non-AO, non-AO to AO, AO to non-AO and AO to AO) and compared the incidence of HT among them.

Figure 4 shows the incidences of HT in the four groups. The incidence was higher in the non-AO to AO group than in the non-AO to non-AO group (45.6% *vs.* 31.8%, $p=0.019$). It was also higher in the AO to AO group than in the AO to non-AO group (58.0% *vs.* 26.7%, $p=0.027$). There was no significant difference in the incidence of HT between the non-AO to non-AO group and the AO to non-AO group ($p=0.782$), or between the non-AO to AO group and the AO

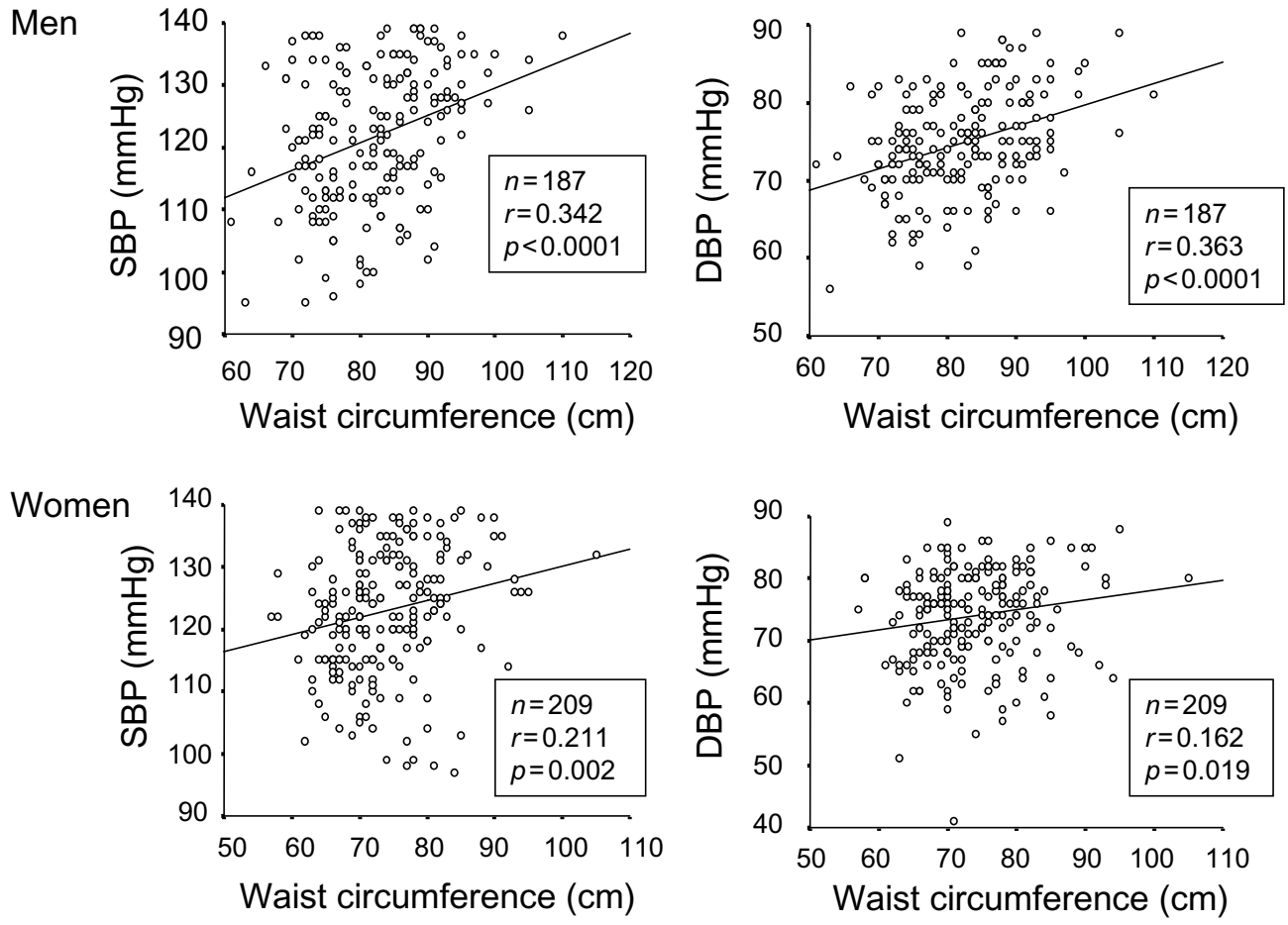

Fig. 1. *Correlations of waist circumference in 1994 with SBP and DBP in 2002. Upper: for men; lower: for women. Graphs on the left are relationships between waist circumference and SBP, and graphs on the right are relationships between waist circumference and DBP. Waist circumference shows significant positive correlations with SBP and DBP in both men and women.*

to AO group ($p=0.142$).

Table 2 shows the results of multiple logistic regression analysis. The relative risk of developing HT in individuals with AO was 2.33 ($p=0.016$; 95% confidence interval [CI], 1.17–4.63), and the risk per 1-cm increase in WC from 1994 to 2002 was 1.06 ($p=0.003$; 95% CI, 1.02–1.10), both adjusted for age, sex, high-normal BP in 1994, smoking (yes/no), FPG, and T.chol. When we additionally adjusted for BMI≥25 (yes/no) in the logistic regression model, the significance of AO disappeared (data not shown).

Discussion

The main findings of this study are 1) the incidence of HT was higher in the AO group than in the non-AO group, 2) increased WC, which may indicate the accumulation of visceral fat, increased the incidence of HT, 3) AO assessed by WC was significantly related to the development of HT (relative risk of HT: 2.33), 4) increasing WC was significantly related to the development of HT after adjustment for 1994 AO.

The Japanese Society of Internal Medicine and eight related scientific societies in Japan jointly announced new Japanese diagnostic criteria for MetS in April 2005 (*1*). According to the new criteria, the definition of MetS must include abdominal obesity, because the accumulation of visceral fat in individuals with MetS is considered to be important for the mechanism underlying the accumulation of risk factors for cardiovascular disease. Accumulation of visceral fat leads to insulin resistance and disorder of adipocytokines, and these factors in turn lead to high BP *via* mechanisms such as an increase in reabsorption of sodium in the renal tubule, hyperactivity of the sympathetic nervous system, proliferation of vascular smooth muscle cells and development of atherosclerosis. The results of this study show that abdominal obesity is significantly related to the development of HT and that an increase in WC, which may indicate the accumulation of visceral fat, is a risk factor for the development of HT.

It is well known that obesity is significantly related to HT, and many reports show relationships between BP levels and

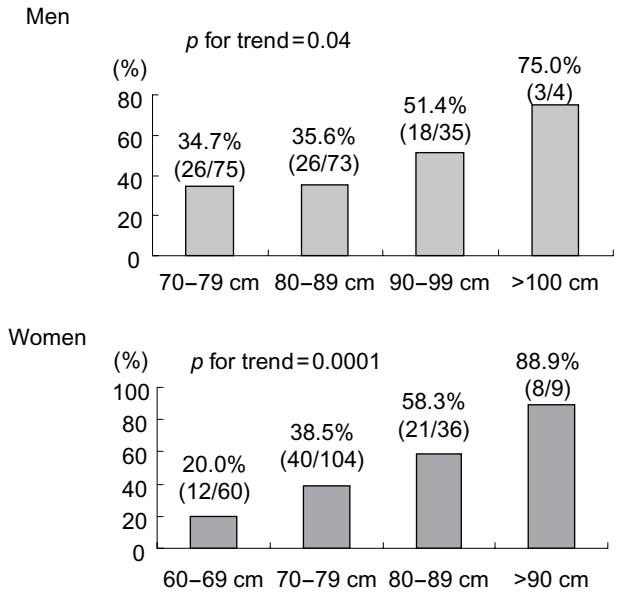

Fig. 2. *Percentage of hypertension (HT) in 2002 in each 1994 waist circumference (WC) category. The higher the WC category, the higher the incidence of HT in both men and women. p for the trend is significant in both men and women.*

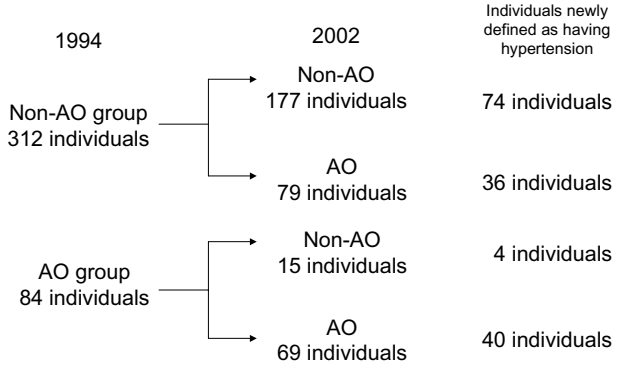

Fig. 3. *Follow-up results. There were 312 individuals in the non-AO group and 84 in the AO group. Of the 312 individuals in the non-AO group, 177 remained in the non-AO category in 2002, but the remaining 79 individuals changed to the AO category in 2002. Sixty-nine of the 84 individuals in the AO group remained in the AO category in 2002, but the remaining 15 individuals changed to the non-AO category in 2002. AO, abdominal obesity. Hypertension (HT): SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg and/or receiving medication for HT.*

various anthropometric parameters (*2–12*). We also have reported a strong correlation between obesity assessed by BMI and the development of HT according to our cohort data (*13*), as well as a correlation between ultrasound-assessed visceral fat accumulation and BP levels (*14*).

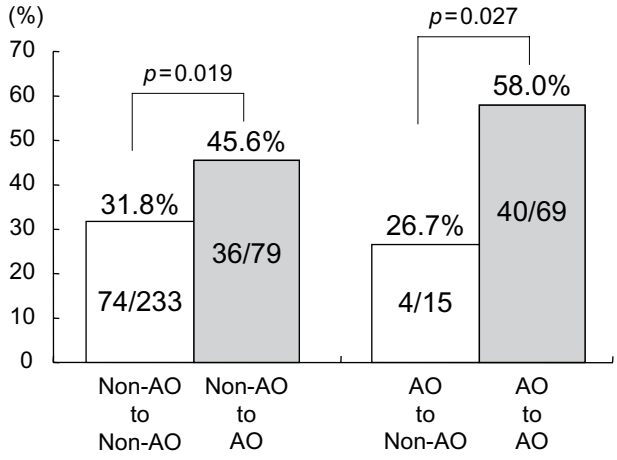

Fig. 4. *Incidences of hypertension (HT) in participants in the four groups. The incidence of HT is higher in the non-AO to AO group than in the non-AO to non-AO group (45.6% vs. 31.8%, p = 0.019). The incidence of HT is also higher in the AO to AO group than in the AO to non-AO group (58.0% vs. 26.7%, p = 0.027). There is no significant difference in the incidence of HT between the non-AO to non-AO group and the AO to non-AO group (p = 0.782), or between the non-AO to AO group and the AO to AO group (p = 0.142). AO, abdominal obesity.*

It is also known that a reduction in body weight leads to a decrease in BP levels (*15–20*). In the present study, no significant difference was found between the incidences of HT in the non-AO to non-AO group and the AO to non-AO group. Although this study was not interventional, the results suggest that weight reduction is effective for the prevention of HT. These results suggest that, to prevent hypertension, lifestyle modification is important for individuals with AO as well as for individuals with high-normal BP.

There are grounds for controversy about the current Japanese cutoff points for abdominal obesity (85 cm for men and 90 cm for women). The International Diabetes Federation (IDF) recommends that Asian cutoff points (90 cm for men and 80 cm for women) should be used for diagnosing MetS in Japanese people (The IDF consensus worldwide definition of the metabolic syndrome. http://www.idf.org/webdata/docs/MetS_def_update2006.pdf [accessed February 7, 2008]). In the present study, the prevalence of abdominal obesity was significantly lower in women than in men. According to Fig. 1, the incidence of HT in women increased continuously with the increase of WC. We tried to plot the receiver operator characteristic (ROC) curves for WC to predict the development of HT in men and women separately. The areas under the curves were 0.560 for men and 0.684 for women. According to the ROC curves, the cutoff levels yielding the maximal sensitivity plus specificity for predicting the development of

Table 2. Relative Risks for Hypertension (HT) in Individuals with Abdominal Obesity (AO)

	Wald	*p*	Relative risk	95% CI
Age	11.28	0.001	1.05	1.02–1.08
Sex	1.07	0.301	1.47	0.71–3.02
High normal category in 1994 (yes/no)*	54.42	<0.0001	6.33	3.84–10.43
Smoking	0.78	0.379	1.34	0.70–2.56
FPG	0.22	0.64	0.99	0.98–1.01
T.chol	0.68	0.41	0.99	0.98–1.01
Abdominal obesity in 1994 (yes/no)[#]	5.78	0.016	2.33	1.17–4.63
ΔWaist circumference (cm)[§]	8.59	0.003	1.06	1.02–1.10

The relative risk for development of HT in individuals with AO was 2.33 ($p=0.016$; 95% CI, 1.17–4.63) and the risk for HT in individuals with increase in waist circumference of 1 cm from 1994 to 2002 was 1.06 ($p=0.003$; 95% CI, 1.02–1.10), both adjusted for age, sex, high normal category of blood pressure in 1994 (yes/no), smoking, FPG and T.chol. *High normal category of blood pressure, SBP≥130 mmHg and/or DBP≥85 mmHg. [#]Abdominal obesity, waist circumference ≥85cm for men and ≥90cm for women. [§]ΔWaist circumference=(waist circumference in 2002) − (waist circumference in 1994). CI, confidence interval; FPG, fasting plasma glucose; T.chol, total cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.

HT were 84 cm for men and 74 cm for women. These results suggest that the current cutoff point in men is acceptable but that a lower cutoff point is appropriate to identify women at high risk for HT. Further studies are needed to establish appropriate cutoff points of WC in the Japanese population.

Despite this controversy, in the present study we used the current Japanese WC cutoff points because the Ministry of Health, Labour and Welfare started a new program of health examinations in Japan in April 2008 (Health Service Bureau, Ministry of Health, Labour and Welfare: Standard program of medical examination and health guidance [fixed version]). The Japanese WC criterion is used to identify high-risk individuals in the new program. Therefore, an accumulation of evidence using the current WC cutoff points is important for medical staff who will be involved in the new health examination program, such as doctors in clinics, public health nurses, and senior nutritionists in local governments. The results of this study showed the usefulness of the current WC cutoff points for identifying individuals at high risk for HT. The results also indicated the possibility that many individuals, especially women, who are at high risk for HT will be missed if attention is given to only abdominal obesity defined by the current cutoff points.

In conclusion, our results suggest that, to prevent HT in Japanese, it is important to manage abdominal obesity and to monitor waist circumference in individuals with or without abdominal obesity.

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