Findings from our study and previous ones suggest WC differs according to the location of the measurement that the magnitude of the difference varies according to sex and ethnicity. In order to compare the prevalence of the metabolic syndrome worldwide, a particular WC site should be defined as the standard. Currently, the NCEP-ATP III, IDF, and WHO each have different WC sites in their guidelines. In the future, these guidelines should be unified and standardized. Furthermore, based on research findings such as those presented herein, ethnicity-specific cutoff values should also be defined.

Such differences in WC measurements inevitably influence the prevalence of the metabolic syndrome. When the NCEP-ATP III criteria in 2005 (90 cm for men and 80 cm for women, values used for Asian populations (17)) for the metabolic syndrome were used with the WC values measured at WC1, WC2, and WC3 rather than at WC4 (the position defined by the NCEP-ATP III criteria), 18, 10, and 3% fewer men and 26, 21, and 11% fewer women, respectively, met the criteria for the metabolic syndrome. Thus, caution should always be exercised when interpreting the prevalence of the metabolic syndrome in studies where the WC was not measured at the site specified by the guidelines that were being used. We proposed to use the regression equation to convert each WC to another to adjust for the difference among WCs measured at different locations because there is a high correlation between each WC measurement site.

In our study, the shapes of the ROCs and their AUCs did not significantly differ among the four WC measurements for either men or women, indicating that measurements at any of the sites have a similar ability to screen for multiple components of the metabolic syndrome. Willis *et al.* measured WC at two locations (WC1 and WC3) among overweight subjects (14) and found that WC1 was more strongly associated with cardiovascular disease risk factors and the metabolic syndrome than WC3. In our study, according to ROC stratified by BMI (<25 and ≥25) to predict multiple risk factors, the AUC did not differ significantly among four WC sites. Such inconsistency may be partly attributable to ethnic differences.

The prevalence of metabolic syndrome is much higher in men than in women according to an epidemiological study of Japanese subjects (18,19) as well as the National Nutrition Survey of Japan (20). Our results were similar to those of previous studies. The AUC for all WC sites measured were much greater in women (0.75–0.78) than in men (0.66–0.67). Although the AUC, derived from sensitivity and specificity, was greater in women than in men, the proportion of people who had two or more risk factors among the screened people (i.e., positive predictive value) was lower in women than in men (e.g., 50.8–52.0% for men and 19.1–22.7% for women, respectively, when sensitivity = 80%) because positive predictive value depended on prevalence of risk factors in the target population. The low positive predictive value could result in the low efficiency of screening, and therefore, we should carefully consider not only sensitivity and specificity but also positive predictive value to compare the performances of WC measurements between men and women in this population.

This finding may be ascribed to lifestyle differences between the sexes. For example, men are much more likely to smoke than women (21), and smoking is known to influence body weight (22). Thus, smoking may attenuate the association between WC measurements and clusters of metabolic risk factors in men.

The major strengths of our study included the large sample size (>1,000 subjects) and the provision of a training session on WC measurements prior to the survey. This study has two limitations. First, given the cross-sectional design, a longitudinal study examining the risk of metabolic syndrome incidence is needed to verify our results. Second, there were relatively few female subjects in this study ($n = 171$). Additional larger studies are required to confirm our findings in women. These limitations should be addressed in future research.

In conclusion, a moderate-to-large difference in WC measurements was observed, depending on the site of measurement, in Japanese adults. The four WC measurements assessed in the present study appear to have similar screening abilities for multiple components of the metabolic syndrome. To ensure accurate comparisons among studies, however, we strongly recommend that the WC be measured at the site specified by the guidelines adopted by each study.

REFERENCES
1. Matsuzawa Y. Metabolic syndrome—definition and diagnostic criteria in Japan. *J Jpn Soc Int Med* 2005;94:188–203.
2. Kadota A, Hozawa A, Okamura T et al.; NIPPON DATA Research Group. Relationship between metabolic risk factor clustering and cardiovascular mortality stratified by high blood glucose and obesity: NIPPON DATA90, 1990-2000. *Diabetes Care* 2007;30:1533–1538.
3. Ninomiya T, Kubo M, Doi Y et al. Impact of metabolic syndrome on the development of cardiovascular disease in a general Japanese population: the Hisayama study. *Stroke* 2007;38:2063–2069.
4. Kato M, Takahashi Y, Inoue M et al.; JPHC Study Group. Comparisons between anthropometric indices for predicting the metabolic syndrome in Japanese. *Asia Pac J Clin Nutr* 2008;17:223–228.
5. Hayashi T, Boyko EJ, McNeely MJ et al. Minimum waist and visceral fat values for identifying Japanese Americans at risk for the metabolic syndrome. *Diabetes Care* 2007;30:120–127.
6. Ross R, Berentzen T, Bradshaw AJ et al. Does the relationship between waist circumference, morbidity and mortality depend on measurement protocol for waist circumference? *Obes Rev* 2008;9:312–325.
7. World Health Organization. Definition, diagnosis and classification of diabetes and its complications: report of a WHO consultation. Geneva, 1999. (WHO/NCD/NCS/99.2)
8. International Diabetes Federation. A new worldwide definition of the metabolic syndrome <http://www.idf.org/home> (2005). Accessed 14 April 2005.
9. Grundy SM, Cleeman JI, Daniels SR et al.; *American Heart Association; National Heart, Lung, and Blood Institute*. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005;112:2735–2752.

10. Lohman TG. Anthropometric Standardization Reference Manual. Human Kinetics: Champaign, IL, 1988, pp 28–80.

11. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics* 1988;44:837–845.

12. Wang J, Thornton JC, Bari S *et al*. Comparisons of waist circumferences measured at 4 sites. *Am J Clin Nutr* 2003;77:379–384.

13. Bigaard J, Spanggaard I, Thomsen BL, Overvad K, Tjønneland A. Self-reported and technician-measured waist circumferences differ in middle-aged men and women. *J Nutr* 2005;135:2263–2270.

14. Willis LH, Slentz CA, Houmard JA *et al*. Minimal versus umbilical waist circumference measures as indicators of cardiovascular disease risk. *Obesity (Silver Spring)* 2007;15:753–759.

15. Mason C, Katzmarzyk PT. Variability in waist circumference measurements according to anatomic measurement site. *Obesity (Silver Spring)* 2009;17:1789–1795.

16. Mason C, Katzmarzyk PT. Effect of the site of measurement of waist circumference on the prevalence of the metabolic syndrome. *Am J Cardiol* 2009;103:1716–1720.

17. Kim JH, Lim YJ, Kim YH *et al*. Is metabolic syndrome a risk factor for colorectal adenoma? *Cancer Epidemiol Biomarkers Prev* 2007;16: 1543–1546.

18. Hara K, Matsushita Y, Horikoshi M *et al*. A proposal for the cutoff point of waist circumference for the diagnosis of metabolic syndrome in the Japanese population. *Diabetes Care* 2006;29:1123–1124.

19. Saito I, Iso H, Kokubo Y, Inoue M, Tsugane S. Metabolic syndrome and all-cause and cardiovascular disease mortality: Japan Public Health Center-based Prospective (JPHC) Study. *Circ J* 2009;73:878–884.

20. Ministry of Health, Labour and Welfare of Japan. Annual report of the National Nutrition Survey in 2006. <http://www.mhlw.go.jp/houdou/2008/04/dl/h0430-2c.pdf>. Accessed 8 October 2009 (in Japanese).

21. Division of Health Promotion and Nutrition, Ministry of Health, Labour and Welfare. Annual report of the National Nutrition Survey in 2005. Daiichi Publishing Co: Tokyo, 2007. (in Japanese).

22. Mizoue T, Ueda R, Tokui N, Hino Y, Yoshimura T. Body mass decrease after initial gain following smoking cessation. *Int J Epidemiol* 1998;27: 984–988.

Associations of Visceral and Subcutaneous Fat Areas With the Prevalence of Metabolic Risk Factor Clustering in 6,292 Japanese Individuals

The Hitachi Health Study

YUMI MATSUSHITA, PHD[1]
TORU NAKAGAWA, MD, PHD[2]
SHUICHIRO YAMAMOTO, MD[2]
YOSHIHIKO TAKAHASHI, MD, PHD[3]

TETSUJI YOKOYAMA, MD, PHD[4]
MITSUHIKO NODA, MD, PHD[3]
TETSUYA MIZOUE, MD, PHD[1]

OBJECTIVE — We examined the relationships of visceral fat area (VFA), subcutaneous fat area, and waist circumference, determined using computed tomography (CT), and BMI with metabolic risk factors in a large Japanese population.

RESEARCH DESIGN AND METHODS — Study subjects comprised 6,292 men and women who participated in the Hitachi Health Study and received CT examinations in 2007 and 2008.

RESULTS — Regarding the clustering of metabolic risk factors, the odds ratios (ORs) for the VFA quintiles were 1.0 (ref.), 2.4, 3.4, 5.0, and 9.7 for men and 1.0 (ref.), 1.5, 2.6, 4.6, and 10.0 for women ($P < 0.001$ for trends in both sexes). For the highest quintiles, the OR for VFA was 1.5 to 2 times higher than those of the other anthropometric indexes in both sexes.

CONCLUSIONS — We demonstrated a superior performance of VFA to predict the clustering of metabolic risk factors compared with other anthropometric indexes.

Diabetes Care 33:2117–2119, 2010

Metabolic syndrome (MS) has been growing globally with the clusters of obesity, high blood pressure, impaired lipid metabolism, and hyperglycemia. Individuals with MS have a higher risk of cardiovascular disease and a subsequent increase in disease mortality or morbidity (1–3). For the diagnosis of MS, waist circumference (WC) is almost always used as one of the criteria, and this measure is typically used as a simplified measure of the visceral fat area (VFA) (4–7). Visceral fat is regarded as an endocrine organ that secretes adipocytokines and other vasoactive substances that can influ-

ence the risk of developing traits of MS (8). A few studies have shown the impact of visceral fat on MS and its components in large-scale epidemiological research efforts (9). The present study analyzed the epidemiological impact of VFA compared with that of subcutaneous fat area (SFA), WC, and BMI against the clustering of metabolic risk factors and its components.

RESEARCH DESIGN AND
METHODS — Of 17,606 employees and their spouses who, after more than 12 h of fasting, underwent a health exam-

ination in Hitachi, Ibaraki Prefecture, between 2007 and 2008, we analyzed data for 6,292 subjects (5,606 men and 686 women), aged 26 to 75 years, who underwent a computed tomography (CT) examination, answered a questionnaire on lifestyle and health, and did not have a history of serious illness (cancer, cerebrovascular disease, or myocardial infarction). VFA, SFA, and WC were measured using a CT scanner according to a protocol described elsewhere (10). The present study was approved by the ethics committee of the National Center for Global Health and Medicine. Written informed consent was obtained from all subjects.

In this study, subjects with two or more of the four risk factors (high blood pressure, high triglyceride, low HDL cholesterol, and hyperglycemia) defined in the criteria of the National Cholesterol Education Program's Adult Treatment Panel III guidelines in 2005 (6), except for WC, were defined as having the clustering of metabolic risk factors. Subjects currently receiving treatment for hyperlipidemia, hypertension, or diabetes were deemed as having the respective risk factors, regardless of the biochemical values.

We divided the subjects into quintiles (Q1 to Q5) according to each anthropometric value and calculated the odds ratio (OR) of the clustering of metabolic risk factors and its components adjusted for age, smoking habits, alcohol consumption, and regular physical activity using a logistic regression analysis, with Q1 as the reference. All analyses were performed using SPSS for Windows, Version 15.0 (SPSS, Chicago, IL).

RESULTS — The mean VFA was 123.7 ± 51.2 cm^2 in men and 85.1 ± 45.2 cm^2 in women. The mean SFA was 134.8 ± 56.6 cm^2 in men and 182.5 ± 72.9 cm^2 in women. The ratio of VFA to SFA was ~1:1 for men and 1:2 for women. The mean WC was 86.4 ± 8.3 cm in men and 83.2 ± 9.2 cm in women.
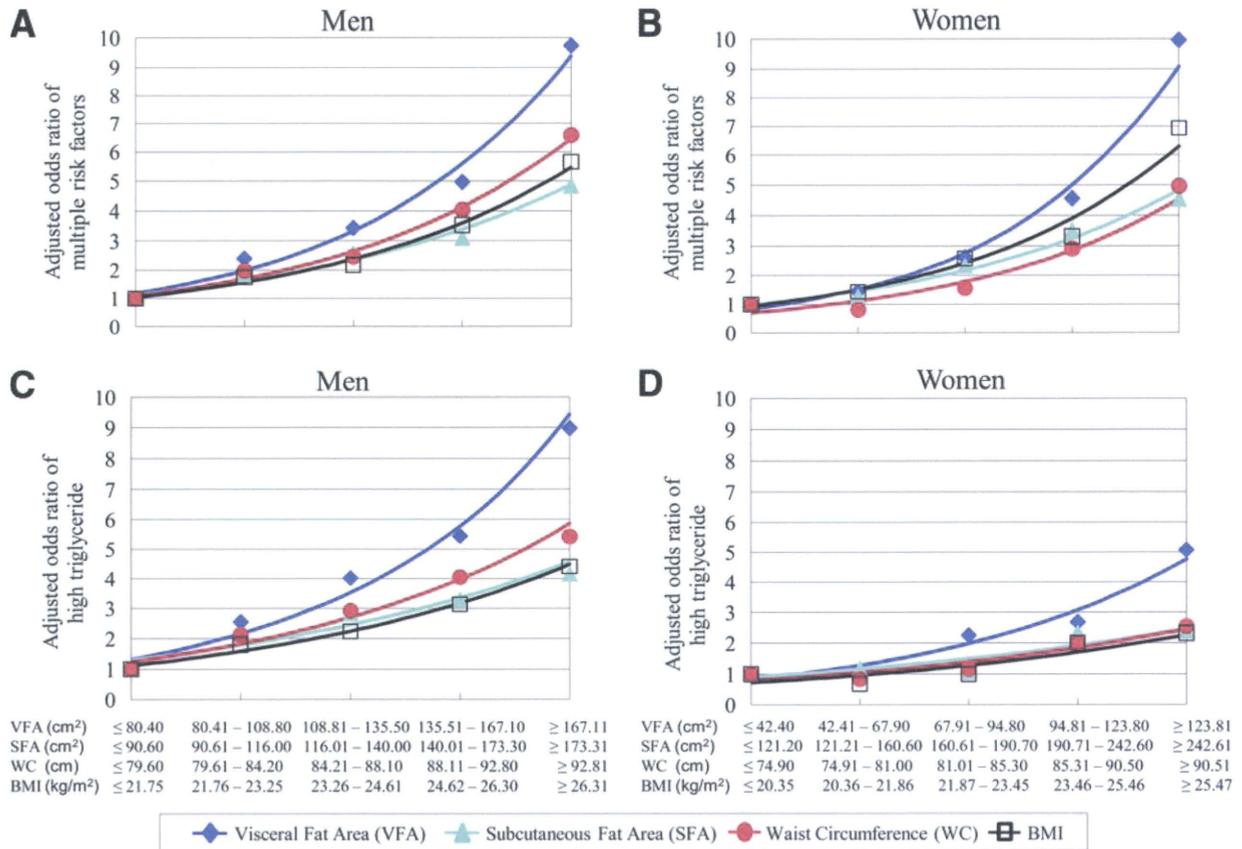
Figure 1—*ORs for high triglyceride and the clustering of metabolic risk factors according to the quintiles (Q1–Q5) of VFA, SFA, WC, and BMI adjusted for age, smoking habits (never, current, past), alcohol consumption (nondrinker, drinker consuming two go or less per day [a go is a conventional unit of alcohol intake in Japan and contains ~23 g of ethanol], or consuming more than two go per day), and regular fitness habit (yes/no). The symbols are the estimated ORs using Q1 as the reference category. The curves are fitted by the logistic regression models. The slope for VFA is significantly steeper than those for SFA, WC, and BMI on high triglyceride and on clustering of metabolic risk factors ($P < 0.05$) except for that on the clustering of metabolic risk factors in women. (A high-quality digital representation of this figure is available in the online issue.)*

The mean BMI was 24.1 ± 3.0 kg/m^2 in men and 23.0 ± 3.3 kg/m^2 in women. The prevalence of the clustering of metabolic risk factors was 46.0% in men and 30.0% in women.

In Fig. 1, the ORs for the clustering of metabolic risk factors are shown according to each anthropometric index. The OR was 1.5 to 2 times higher for the Q5 VFA category than for the other Q5 categories for both men and women. The OR (95% CI) of the VFA quintiles were, respectively, 1.0, 2.4 (2.0–2.9), 3.4 (2.8–4.2), 5.0 (4.1–6.0), and 9.7 (8.0–11.9) for men and 1.0, 1.5 (0.7–3.2), 2.6 (1.3–5.3), 4.6 (2.3–9.1), and 10.0 (5.0–19.9) for women ($P < 0.001$ for trends in both sexes). According to the SFA quintiles, ORs were, respectively, 1.0, 1.8 (1.5–2.2), 2.6 (2.2–3.1), 3.1 (2.6–3.7), and 4.8 (4.0–5.8) for men and 1.0, 1.3 (0.7–2.5), 2.3 (1.3–4.3), 3.5 (1.9–6.4), and 4.5 (2.5–8.4) for women ($P < 0.001$ for trends in both sexes).

The OR for a high triglyceride level, a low HDL level, high blood pressure, and hyperglycemia increased with increasing quintile categories of each anthropometric index. The OR (95% CI) of the Q5 VFA category for a high triglyceride level was 9.0 (7.3–11.1) in men and for a low HDL level was 7.1 (4.8–10.5) in men and 11.0 (4.0–30.1) in women, exhibiting extremely high ORs.

The slope for VFA is significantly steeper than those for SFA, WC, and BMI on high triglyceride and on clustering of metabolic risk factors ($P < 0.05$) except for the slope on the clustering of metabolic risk factors in women.

CONCLUSIONS — In the present study, a stronger association between an increasing VFA and the clustering of metabolic risk factors and its components than for an increasing SFA, WC, or BMI was observed. Among metabolic risk factors, a high triglyceride level in men and a low HDL cholesterol level in both men

and women showed particularly strong associations with VFA.

BMI and WC are used clinically to measure obesity, but do not exactly reflect visceral adiposity. A previous report showed that some individuals with a normal BMI and WC actually had an excessive amount of visceral fat and metabolic risk factors (11). In our study, the ORs for the clustering of metabolic risk factors were similar for BMI and WC in men, but the OR for WC was lower than that for BMI (which was similar to that for SFA) in women. The OR of VFA and SFA differed according to sex. Furthermore, a stronger correlation was observed between WC and SFA than between WC and VFA. Fox et al. (9) reported similar results. These findings suggest that WC measurements in women may have the same meaning as SFA measurements, explaining the similarity of the OR for the clustering of metabolic risk factors in WC and SFA.

The present study adds evidence to support an important role for VFA in the

22

pathogenesis of metabolic risk factor clustering in Japanese adults. Further studies are needed to confirm this association prospectively and to examine the impact of VFA on the risk of cardiovascular disease.

References

1. Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, Salonen JT. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. JAMA 2002;288: 2709–2716
2. Isomaa B, Almgren P, Tuomi T, Forsén B, Lahti K, Nissén M, Taskinen MR, Groop L. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care 2001;24:683–689
3. Grundy SM, Brewer HB Jr, Cleeman JI, Smith SC Jr, Lenfant C, American Heart Association, National Heart, Lung, and Blood Institute. American Heart Association, National Heart, Lung, and Blood Institute. Definition of metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 2004;109:433–438
4. World Health Organization. *Definition, Diagnosis and Classification of Diabetes and its Complications: Report of a WHO consultation.* Geneva, World Health Org., 1999
5. A new worldwide definition of the metabolic syndrome [article online], 2005. Brussels, Belgium, International Diabetes Federation. Available from http://www.idf.org/node/1271?unode=1120071E-AACE-41D2-9FA0-BAB6E25BA072. Accessed 3 July 2009
6. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC Jr, Spertus JA, Costa F, American Heart Association, National Heart, Lung, and Blood Institute. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005;112:2735–2752
7. Matsuzawa Y. Metabolic syndrome—definition and diagnostic criteria in Japan. J Atheroscler Thromb 2005;12:301
8. Wajchenberg BL. Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. Endocr Rev 2000; 21:697–738
9. Fox CS, Massaro JM, Hoffmann U, Pou KM, Maurovich-Horvat P, Liu CY, Vasan RS, Murabito JM, Meigs JB, Cupples LA, D'Agostino RB Sr, O'Donnell CJ. Abdominal visceral and subcutaneous adipose tissue compartments: association with metabolic risk factors in the Framingham Heart Study. Circulation 2007;116:39–48
10. Yamamoto S, Nakagawa T, Matsushita Y, Kusano S, Hayashi T, Irokawa M, Aoki T, Korogi Y, Mizoue T. Visceral fat area and markers of insulin resistance in relation to colorectal neoplasia. Diabetes Care 2010; 33:184–189
11. Ross R, Rissanen J, Hudson R. Sensitivity associated with the identification of visceral adipose tissue levels using waist circumference in men and women: effects of weight loss. Int J Obes Relat Metab Disord 1996;20:533–538

Associations of Smoking Cessation With Visceral Fat Area and Prevalence of Metabolic Syndrome in Men: The Hitachi Health Study

Yumi Matsushita[1], Toru Nakagawa[2], Shuichiro Yamamoto[2], Yoshihiko Takahashi[3], Mitsuhiko Noda[3] and Tetsuya Mizoue[1]

Weight gain after smoking cessation may deteriorate metabolic risk profiles, including that for metabolic syndrome. How risk profiles change according to the duration of smoking cessation and whether the visceral fat area (VFA) or the subcutaneous fat area (SFA) contributes to these changes remains uncertain. The subjects comprised 5,697 Japanese men who underwent an abdominal computed-tomography examination during a health check-up. Using never smokers as a reference group, the odds ratios of having metabolic syndrome and its components, defined using the National Cholesterol Education Program Adult Treatment Panel IIIcriteria, were calculated for each smoking category with adjustments for age, alcohol drinking, and physical activity (model 1) using a logistic regression analysis. Additional adjustments were also made for either VFA (model 2) or SFA (model 3). Current smokers had the lowest VFA ($120.4\,cm^2$) whereas ex-smokers ($124.0–132.0\,cm^2$) had a higher VFA than nonsmokers ($123.1\,cm^2$). Among the ex-smokers, VFA tended to decrease with increasing years of smoking cessation. In model 1, the odds ratios of having metabolic syndrome for current smokers and ex-smokers with smoking cessation for ≤4, 5–9, 10–14, and ≥15 years were 1.02, 1.33, 1.36, 1.40, and 1.09, respectively. The elevated odds ratios among ex-smokers (≤14 years) were reduced by 35–55.6% after further adjustment for VFA but not for SFA. Smoking cessation is associated with a deterioration of the metabolic risk profile, which can be ascribed, at least in part, to an increase in VFA not SFA.

INTRODUCTION

Metabolic syndrome is associated with an increased risk of cardiovascular mortality or morbidity (1,2). BMI is a measure of overall obesity, but the importance of central obesity, which can be easily measured as waist circumference, is known to have a stronger relation to the prevalence of each component of metabolic syndrome (hyperglycemia, diabetes, and hypertension) than BMI (3).

Numerous studies have investigated the relationship between smoking and body weight or BMI. Cigarette smokers tend to have a lower BMI than nonsmokers (4–6), and smoking cessation leads to weight gain to various extents (4,7,8). This difference or change in body weight can be ascribed to an increased metabolic rate and decreased caloric absorption by smoking (9).

Because weight gain deteriorates metabolic profiles (10), whether weight gain following smoking cessation leads to an increased risk of metabolic syndrome is a concern. However, epidemiologic data on the prevalence of metabolic syndrome according to the duration of smoking cessation are limited. Moreover, which type of fat deposition, the visceral fat area (VFA) or the subcutaneous fat area (SFA), contributes to these changes after smoking cessation is uncertain. Here, we assessed the prevalence of metabolic syndrome and its risk components in relation to the duration of smoking cessation and examined the contribution of VFA and SFA to an increased prevalence, if any, of metabolic syndrome after smoking cessation.

METHODS AND PROCEDURES

Overall, a total of 15,196 male employees and their spouses underwent a annual health check-up after having fasted overnight. All the examinations were performed in 2007 in Hitachi, Ibaraki prefecture. Of these participants, 6,405 subjects received an abdominal computed-tomography (CT) scan. We next excluded 708 subjects who did not provide lifestyle information regarding smoking, physical activity, or alcohol drinking. Finally, 5,697 men aged between 26 and 75 years were included in the analysis.

Body height and weight were measured using an automated scale (BF-220; TANITA; Itabashi-Ku, Tokyo, Japan), and the BMI was defined as weight/height^2 (kg/m^2). VFA, SFA, and waist circumference

[1]Department of Epidemiology and International Health, National Center for Global Health and Medicine, Tokyo, Japan; [2]Hitachi, Ltd., Hitachi Health Care Center, Ibaraki, Japan; [3]Department of Diabetes and Metabolic Medicine, National Center for Global Health and Medicine, Tokyo, Japan. Correspondence: Yumi Matsushita (ymatsushita@ri.ncgm.go.jp)

were measured using a CT scanner, the details of which are described elsewhere (11). In brief, single slice imaging was performed at the umbilical level in a spine position using a CT machine (Redix Turbo; Hitachi Medico, Chiyoda-Ku, Tokyo). The imaging conditions were 120 kV, 50 mA, and a slice thickness of 5 mm. VFA, SFA, and waist circumference were calculated using the software fatPointer (Hitachi Medico).

The triglyceride and high-density lipoprotein (HDL) cholesterol levels were measured using the oxygen method (Hitachi 7600; Sekisui Medical; Chuo-Ku, Tokyo, Japan). The blood glucose level was measured using the glucose electrode technique (ADAMS glucose GA-1170; Arkrey; Chukyo-Ku, Kyoto, Japan). Blood pressure was measured using an oscillometric method (Kentaro ADVANCE BP-203RV III A/B; Colin; Bunkyo-Ku, Tokyo, Japan). Written informed consent was obtained from each participant. The present study was approved by the ethics review committee of the National Center for Global Health and Medicine.

The subjects were divided into six groups: nonsmokers, current smokers, and ex-smokers with ≤4, 5–9, 10–14, and ≥15 years of smoking cessation. We tested the difference between current smokers and other smoking status groups using pair-wise test after analysis of covariance adjusted for age, regular physical activity (yes/no), and alcohol drinking (nondrinker, drinker consuming 2 go or less per day (one go contains ~23 g of ethanol), or drinker consuming ≥2 go per day). The multiple comparisons were adjusted by Bonferroni's method (five comparisons).

Using nonsmokers as the reference, we calculated the odds ratios of (i) waist circumference (≥90 cm), (ii) high triglyceride level (≥150 mg/dl), (iii) low HDL cholesterol level (<40 mg/dl), (iv) high blood pressure (systolic blood pressure ≥130 mm Hg and/or diastolic blood pressure ≥85 mm Hg), (v) hyperglycemia (fasting glucose level ≥110 mg/dl), and (vi) metabolic syndrome as defined using the National Cholesterol Education Program Adult Treatment Panel III criteria (having three or more of components (i) to (v) listed above), adjusted for age, regular physical activity (yes/no), and alcohol drinking (nondrinker, drinker consuming 2 go or less per day, or drinker consuming ≥2 go per day) (model 1). Additional analyses were adjusted for VFA (model 2) or SFA (model 3). All analyses were performed using logistic regression analysis. Subjects currently receiving treatment for hyperlipidemia, hypertension, or diabetes were deemed as having the respective risk factors, regardless of their biochemical values ((ii) to (vi)). All analyses were performed using SPSS for Windows, version 15.0 (SPSS, Chicago, IL).

RESULTS

The subject characteristics are shown in **Table 1**. The mean (s.d.) age of the subjects was 52.7 (10.0) years, the mean (s.d.) BMI was 24.1 (3.0) kg/m^2, and the mean (s.d.) VFA was 124.0 (51.2) cm^2. The prevalence of metabolic syndrome was 19.2%.

Table 1 Characteristics of the subjects

	Mean (s.d.)
n	5,697
Age, years	52.7 (10.0)
BMI, kg/m^2	24.1 (3.0)
Waist circumference, cm	86.4 (8.3)
Visceral fat area, cm^2	124.0 (51.2)
Subcutaneous fat area, cm^2	134.8 (56.5)
High blood pressure, %	38.1
High triglyceride, %	35.3
Low HDL cholesterol, %	10.0
Hyperglycemia, %	26.9
Metabolic syndrome, %	19.2

The means of the anthropometric indexes according to smoking status are shown in **Table 2**. Current smokers had the lowest VFA (120.4 cm^2), whereas ex-smokers (124.0 to 132.0 cm^2) had a higher VFA than nonsmokers (123.1 cm^2). Among ex-smokers, the VFA tended to decrease with increasing years of smoking cessation, and those with ≥15 years of smoking cessation had almost the same VFA as nonsmokers. Similar results were observed for SFA and waist circumference. Current smokers had a lower mean BMI and waist circumference than nonsmokers and ex-smokers. Ex-smokers with <15 years of smoking cessation had a higher mean waist circumference than nonsmokers, whereas ex-smokers with ≥15 years of smoking cessation had a mean BMI and waist circumference similar to those of nonsmokers.

The odds ratios of having metabolic syndrome and its components according to smoking status are shown in **Table 3**. For metabolic syndrome, the odds ratios for current smokers and ex-smokers with smoking cessation for ≤4, 5–9, 10–14, and ≥15 years were 1.02, 1.33, 1.36, 1.40, and 1.09, respectively. The odds ratio for ex-smokers with ≥15 years of smoking cessation was almost the same as nonsmokers. The odds ratios of metabolic syndrome for ex-smokers with ≤4 years of smoking cessation in model 1 (1.33, 95% CI: 1.04–1.70) was reduced after adjustment for VFA (1.16, 95% CI: 0.88–1.53) but remained basically unchanged after adjustment for SFA (1.46, 95% CI: 1.12–1.90). Similar results were obtained in other groups with different periods of smoking cessation. The odds ratios of having metabolic syndrome for ex-smokers with ≤4, 5–9, and 10–14 years of smoking cessation after adjustment for VFA (model 2) were 1.16, 1.16, and 1.26, respectively; these values were 51.5%, 55.6%, and 35% lower than the values without adjustment for VFA, respectively.

Regarding high blood pressure, current smokers had a significantly lower odds ratio than nonsmokers (0.71; 95% CI: 0.61–0.82). Ex-smokers, irrespective of the length of period of smoking cessation, had almost the same odds ratio as nonsmokers. Regarding high triglyceride levels, current smokers had a significantly higher odds ratio (1.30; 95% CI: 1.13–1.50). Also, ex-smokers with ≤4 and 10–14 years of smoking cessation had significantly increased odds ratios of 1.26 (95% CI: 1.03–1.55) and 1.36 (95% CI: 1.04–1.79), respectively. Regarding low HDL cholesterol levels, current smokers had a significantly higher odds ratio of 1.65 (95% CI: 1.32–2.06). The odds ratios of ex-smokers were not significantly different from that of nonsmokers. Regarding hyperglycemia, the odds ratio (95% CI) of current smokers was 1.08 (0.93–1.27). On the other hand, the odds ratios (95% CI) of ex-smokers with ≤4, 5–9, and 10–14 years of smoking cessation were 1.44 (1.16–1.80), 1.50 (1.19–1.88), and 1.44 (1.07–1.92), respectively.

DISCUSSION

In this study, we examined the association of smoking cessation and metabolic syndrome and its components while considering the potential influence of VFA and SFA. We found that VFA, SFA, and the prevalence of metabolic syndrome were higher among ex-smokers (<15 years of smoking cessation) than

Table 2 Mean values of anthropometric indexes of subjects according to smoking status

| | Nonsmokers | Ex-smokers (years of smoking cessation) | | | | Current smokers |
		≥15	10–14	5–9	≤4	
n	1,578	734	256	461	530	2,138
BMI, kg/m²	24.3 (0.1)**	24.3 (0.1)*	24.4 (0.2)	24.5 (0.1)***	24.1 (0.1)	23.9 (0.1)
Waist circumference, cm	86.4 (0.2)	86.4 (0.3)	87.2 (0.5)	87.7 (0.4)***	87.0 (0.4)*	85.9 (0.2)
Visceral fat area, cm²	123.1 (1.3)	124.0 (1.9)	131.7 (3.2)**	132.0 (2.4)***	130.6 (2.2)***	120.4 (1.1)
Subcutaneous fat area, cm²	137.7 (1.4)***	136.0 (2.1)*	139.9 (3.4)*	142.9 (2.6)***	136.1 (2.4)	129.6 (1.2)
Visceral fat/subcutaneous fat area	0.95 (0.01)*	0.96 (0.01)	1.00 (0.02)	0.97 (0.02)	1.01 (0.02)	0.98 (0.01)

Note: Values are mean (s.e.) adjusted for age, regular physical activity, and alcohol drinking.
*P value <0.05, **P value <0.01, ***P value <0.001 (compared with current smokers).

Table 3 Association of period of smoking cessation with metabolic syndrome and its components

| | | Nonsmokers (Reference) | Ex-smokers (years of quitting) | | | | Current smokers |
			≥15	10–14	5–9	≤4	
n		1,578	734	256	461	530	2,138
Waist circumference	Model 1	1	1.01 (0.83–1.23)	1.11 (0.83–1.48)	1.33 (1.07–1.66)*	1.13 (0.91–1.40)	0.94 (0.81–1.09)
High blood pressure	Model 1	1	1.01 (0.84–1.22)	1.17 (0.89–1.55)	1.04 (0.83–1.29)	0.98 (0.80–1.21)	0.71 (0.61–0.82)*
	Model 2	1	1.00 (0.83–1.22)	1.08 (0.81–1.43)	0.95 (0.76–1.19)	0.91 (0.73–1.13)	0.72 (0.62–0.83)*
	Model 3	1	1.03 (0.85–1.24)	1.16 (0.87–1.53)	1.00 (0.80–1.25)	1.00 (0.80–1.23)	0.75 (0.64–0.86)*
High Triglyceride	Model 1	1	1.11 (0.92–1.35)	1.36 (1.04–1.79)*	1.13 (0.91–1.41)	1.26 (1.03–1.55)*	1.30 (1.13–1.50)*
	Model 2	1	1.11 (0.91–1.36)	1.26 (0.94–1.67)	1.01 (0.80–1.28)	1.16 (0.94–1.45)	1.38 (1.19–1.60)*
	Model 3	1	1.13 (0.93–1.38)	1.36 (1.03–1.79)*	1.10 (0.88–1.37)	1.29 (1.04–1.59)*	1.39 (1.21–1.60)*
Low HDL cholesterol	Model 1	1	0.83 (0.60–1.16)	1.02 (0.64–1.65)	1.19 (0.83–1.70)	1.05 (0.74–1.50)	1.65 (1.32–2.06)*
	Model 2	1	0.82 (0.59–1.15)	0.96 (0.59–1.56)	1.08 (0.75–1.55)	0.98 (0.68–1.40)	1.70 (1.36–2.13)*
	Model 3	1	0.85 (0.61–1.18)	1.01 (0.62–1.63)	1.15 (0.81–1.65)	1.07 (0.75–1.53)	1.76 (1.40–2.20)*
Hyperglycemia	Model 1	1	1.08 (0.88–1.32)	1.44 (1.07–1.92)*	1.50 (1.19–1.88)*	1.44 (1.16–1.80)*	1.08 (0.93–1.27)
	Model 2	1	1.08 (0.88–1.33)	1.36 (1.01–1.83)*	1.41 (1.12–1.79)*	1.37 (1.10–1.72)*	1.11 (0.94–1.30)
	Model 3	1	1.10 (0.90–1.34)	1.43 (1.07–1.91)*	1.47 (1.17–1.85)*	1.47 (1.17–1.83)*	1.13 (0.97–1.33)
Metabolic syndrome	Model 1	1	1.09 (0.87–1.36)	1.40 (1.02–1.92)*	1.36 (1.05–1.75)*	1.33 (1.04–1.70)*	1.02 (0.86–1.22)
	Model 2	1	1.08 (0.84–1.39)	1.26 (0.89–1.80)	1.16 (0.87–1.54)	1.16 (0.88–1.53)	1.06 (0.87–1.29)
	Model 3	1	1.16 (0.91–1.48)	1.42 (1.01–2.00)*	1.32 (1.01–1.73)*	1.46 (1.12–1.90)*	1.18 (0.97–1.42)

Note: Values are odds ratios adjusted for age, physical activity, and alcohol drinking.
Waist circumference ≥ 85 cm. High blood pressure: systolic blood pressure ≥130 mm Hg and/or diastolic blood pressure ≥85 mm Hg. Triglyceride ≥150 mg/dl. HDL cholesterol <40 mg/dl. Impaired fasting glucose: fasting glucose ≥110 mg/dl. Model 1: Values are odds ratios adjusted for age, regular physical activity, and alcohol drinking. Model 2: Values are odds ratios adjusted for age, regular physical activity, and alcohol drinking, and visceral fat area. Model 3: Values are odds ratios adjusted for age, regular physical activity, and alcohol drinking, and subcutaneous fat area.
*P < 0.05 compared with nonsmokers.

among nonsmokers and current smokers. However, the odds ratio of metabolic syndrome among ex-smokers was decreased after adjustment for VFA but not for SFA. Furthermore, the odds ratios of metabolic syndrome and its component for ex-smokers with ≥15 years of smoking cessation were almost the same as those for nonsmokers, though ex-smokers with ≤14 years of smoking cessation generally had higher odds ratios than nonsmokers.

Several previous studies have reported the risk of metabolic syndrome after smoking cessation. Ishizaka et al. assessed the prevalence of metabolic syndrome according to the duration of smoking cessation; using subjects who had never smoked as the reference group, the odds ratios (95% CI) for ex-smokers with <1, 1–4, and ≥5 years of smoking cessation were 2.17 (1.36–3.46), 1.97 (1.33–2.92), and 1.61 (1.26–2.08), respectively (12). Similarly, Wada et al. showed that the odds ratios (95% CI) for ex-smokers (who smoked 20–39 cigarettes per day) with ≤5, 6–10, 11–20, and >20 years of smoking cessation were 1.48 (1.21–1.81), 1.52 (1.16–2.00), 1.25 (1.01–1.54), and 1.09 (0.86–1.39), respectively (13). Both studies found that the odds ratios of metabolic syndrome among ex-smokers tended to decrease with an increasing duration of smoking cessation, similar to the results of the present study. Further, we found that the prevalence of metabolic syndrome and its components among ex-smokers who had quit ≥15 years ago was similar to those among nonsmokers. Hence, the risk of metabolic

syndrome returns to the level of nonsmokers after 15–20 years of smoking cessation.

Smokers often gain weight after they have quit smoking (4,6). However, which component of body fat (VFA, SFA, or both) increases after smoking cessation and how these changes influence the clustering of metabolic risk factors remain uncertain. In the present study, both the VFA and the SFA were larger in ex-smokers than in current smokers, as was the odds ratio of metabolic syndrome. The increased odds ratio of metabolic syndrome among ex-smokers for ≤14 years decreased by 35% to 55.6 % after adjustment for VFA, whereas no appreciable change was seen after adjustment for SFA, suggesting that VFA has an important contribution to the increased prevalence of metabolic syndrome after smoking cessation.

Regarding glucose metabolism, the odds ratios of hyperglycemia were higher among ex-smokers with <15 years of smoking cessation than among current smokers. The increased odds ratios among the ex-smokers (≤14 years of smoking cessation) were decreased by 15.9% to 18.2% after adjustment for VFA but remained basically unchanged after adjustment for SFA. This finding suggests that the increased prevalence of hyperglycemia after smoking cessation might only partly contribute to the increase in VFA and that hyperglycemia among ex-smokers (≤14 years of smoking cessation) might be caused by mechanisms other than those associated with an increased VFA. For example, smoking might directly increase insulin resistance (9), and this adverse effect of smoking on glucose metabolism might persist for several years after smoking cessation.

Current smokers had a higher odds ratio of having high triglyceride levels despite their relatively lower BMI or VFA, compared with the never-smoking group. This finding suggests that smoking had a strong influence on lipid metabolism that extended beyond its weight-reducing effect. The increased odds ratios for high triglyceride levels among ex-smokers with ≤4 years of smoking cessation was decreased by 38.5% after adjustment for VFA but was unchanged after adjustment for SFA. This finding suggests that an increase in VFA partially accounts for the increase in triglyceride levels after smoking cessation. The association of smoking with HDL cholesterol was similar to that for triglycerides. One exception is that the odds ratio of low HDL cholesterol was increased among current smokers, but not among ex-smokers despite their relatively higher VFA. This finding suggests that the favorable effect of smoking cessation on HDL cholesterol is much greater than the adverse effect of an increase in VFA following smoking cessation.

Current smokers had a significantly lower odds ratio of having high blood pressure, compared with never smokers, whereas the odds ratios among ex-smokers were similar to that among never smokers. Blood pressure is known to increase after smoking (14). However, as indicated by the present report and another epidemiologic study (15), smoking might have a blood pressure lowering effect over the long term. The mechanism whereby smoking decreases blood pressure is not clear.

Because development of coronary heart disease were predictive of smoking cessation (16), the inverse causality of the relationship between smoking cessation and metabolic syndrome may happen. To examine this point, we analyzed the data excluding the subjects currently receiving treatment for hyperlipidemia, hypertension, or diabetes, however, the results shown in Table 3 were materially unchanged.

The present study has several strengths and limitations. As one of its strengths, we directly assessed abdominal fat accumulation using CT scanning. This allowed the role of fat deposition in the development of metabolic syndrome and its components after smoking cessation to be examined more closely. Second, the sample size of our study was sufficiently large (>5,500 subjects). Third, we adjusted for alcohol drinking and physical activity, which might confound the association between smoking status and metabolic risk factors. Our study has some limitations. First, only men were analyzed. The prevalence of smoking among men and among women is quite different in Japan (39.4% in men, 11.0% in women) (17), and the prevalence of being overweight (>25 kg/m²) also differs between sexes (30.4% in men, 20.2% in women) (17). Thus, the present results may not be applicable to women. Second, the present study had a cross-sectional design, and changes in the metabolic risk profile during the course of smoking cessation were not monitored. Because of the possibility of inverse causality (i.e., people who developed cardiovascular diseases may tend to quit smoking), we also analyzed data excluding subjects currently receiving medication for hyperlipidemia, hypertension, or diabetes, and confirmed the same results. Therefore, it was unlikely that the inverse causality strongly biased the relationships of smoking status with the metabolic syndrome and its components. A longitudinal study is needed to confirm the present findings. Third, we did not search the dietary intake of our participants, so we could not examine whether increased calorie intake and greater fat intake are independently associated with increased VFA and grew worse in metabolic risk factors.

Smoking cessation was associated with an increased prevalence of metabolic syndrome and its components, which could be accounted for, at least in part, by an increase in VFA but not in SFA in men. After 15 years of smoking cessation, the prevalence of metabolic syndrome returned to the level of nonsmokers. Advising individuals who try to quit smoking to adopt healthy lifestyles, including regular physical activity and a low calorie diet, should be considered to minimize the increase in VFA after smoking cessation.

REFERENCES
1. Lakka HM, Laaksonen DE, Lakka TA et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 2002;288:2709–2716.
2. Isomaa B, Almgren P, Tuomi T et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care* 2001;24: 683–689.

3. International Diabetes Federation. A new worldwide definition of the metabolic syndrome [article online], 2005. <http://www.idf.org/>. Accessed 14 April 2005.
4. Williamson DF, Madans J, Anda RF *et al*. Smoking cessation and severity of weight gain in a national cohort. *N Engl J Med* 1991;324:739–745.
5. Shimokata H, Muller DC, Andres R. Studies in the distribution of body fat. III. Effects of cigarette smoking. *JAMA* 1989;261:1169–1173.
6. Flegal KM, Troiano RP, Pmuk ER, Kuczmarski RJ, Campbell SM. The influence of smoking cessation on the prevalence of overweight and obesity in the United States. *N Engl J Med* 1995;333:1165–1170.
7. Klesges RC, Winders SE, Meyers AW *et al*. How much weight gain occurs following smoking cessation? A comparison of weight gain using both continuous and point prevalence abstinence. *J Consult Clin Psychol* 1997;65:286–291.
8. Swan GE, Carmelli D. Characteristics associated with excessive weight gain after smoking cessation in men. *Am J Public Health* 1995;85:73–77.
9. Chiolero A, Faeh D, Paccaud F, Cornuz J. Consequences of smoking for body weight, body fat distribution, and insulin resistance. *Am J Clin Nutr* 2008;87:801–809.
10. Bonithon-Kopp C, Raison J, Courbon D *et al*. Relationships between 3-y longitudinal changes in body mass index, waist-to-hip ratio, and metabolic variables in an active French female population. *Am J Clin Nutr* 1992;56:475–482.
11. Nakagawa T, Yamamoto S, Irokawa M. Development of the automated diagnosis CT screening system for visceral obesity. *Asian Pac J Dis Manag* 2008; 2:31–38.
12. Ishizaka N, Ishizaka Y, Toda E *et al*. Association between cigarette smoking, metabolic syndrome, and carotid arteriosclerosis in Japanese individuals. *Atherosclerosis* 2005;181:381–388.
13. Wada T, Urashima M, Fukumoto T. Risk of metabolic syndrome persists twenty years after the cessation of smoking. *Intern Med* 2007;46: 1079–1082.
14. Omvik P. How smoking affects blood pressure. *Blood Press* 1996;5:71–77.
15. Green MS, Jucha E, Luz Y. Blood pressure in smokers and nonsmokers: epidemiologic findings. *Am Heart J* 1986;111:932–940.
16. Freund KM, D'Agostino RB, Belanger AJ, Kannel WB, Stokes J 3rd. Predictors of smoking cessation: the Framingham Study. *Am J Epidemiol* 1992;135:957–964.
17. Division of Health Promotion and Nutrition, Ministry of Health, Labour and Welfare. Annual Report of the National Nutrition Survey in 2006. <http://www-bm.mhlw.go.jp/houdou/2008/12/dl/h1225-5d.pdf> (2006) Accessed 13 Nov 2009 (in Japanese).

厚生労働科学研究研究費・
研究成果等普及啓発事業
研究成果発表会（一般向け）

参加者：145名

本シンポジウムに対するアンケート調査では、回答者全員から"また参加したい"という答えが得られ、肥満、メタボリックシンドロームの現況、予防法などを一般市民に広めることができた。

おなかによく効く市民公開講座
メタボ退治にどう立ち向かうか？！
ー目からウロコの"はらいっぱい"ばなしー

日時：平成21年8月7日（金）13:00～16:00　開場12:30
会場：東京国際フォーラム　ガラス棟G701
〒100-0005 東京都千代田区丸の内3丁目5-1

13:00～13:05　開会の挨拶　松下由実（国立国際医療センター研究所 国際保健医療研究部 室長）

[司会] 溝上哲也（国立国際医療センター研究所 国際保健医療研究部長）

13:05～13:35　内臓脂肪を減らすための"はらすまダイエット"
中川徹（日立製作所 日立健康管理センタ 主任医長）

13:35～14:05　"ウォーキングマイレージ"によるメタボ解消
本田律子（国立国際医療センター 糖尿病・代謝症候群診療部 医長）

14:05～14:20　休憩

14:20～14:50　内臓脂肪が生活習慣病に及ぼす影響
ー世界最大規模の疫学研究ー
松下由実

[司会] 高橋義彦（国立国際医療センター 糖尿病・代謝症候群診療部 医長）

14:50～15:20　体格と病気の不思議な関係
溝上哲也

パネルディスカッション
[司会] 野田光彦（国立国際医療センター 糖尿病・代謝症候群診療部長）

15:25～15:55　これからのメタボリックシンドローム撃退作戦
パネラー：中川徹、本田律子、松下由実、溝上哲也、
木下美鳥（厚生労働省健康局 総務課生活習慣病対策室 生活習慣病対策係 生活習慣病対策推進室）

15:55～16:00　閉会の挨拶　野田光彦

参加費：無料
定員：190名

事前の申し込みは必要ありません。190名に達した場合にはご入場いただけませんので、お早めにご来場ください。

JR線 有楽町駅より徒歩1分
東京駅より徒歩5分

主催：松下由実（国立国際医療センター研究所 国際保健医療研究部 室長）
共催：（財）国際協力医学研究振興財団

お問い合わせ：
〒162-8655 東京都新宿区戸山1-21-1
TEL:03-3202-7181(内線2858) 担当・齋藤（祐）
Eメール：metabosymposium@yahoo.co.jp

（厚生労働科学研究補助金（循環器病等総合研究事業）「糖尿病・メタボリックシンドロームにおける内臓脂肪蓄積の評価に関する疫学研究」）

メタボ診断基準 再検討が必要

必ずしも腹囲と内臓脂肪の動きが
いっしょではない…ことが明らかになった

01:40　｜　一時停止

⇔ 動画形式を変更する

▷ もっと詳しく

2月15日 12時7分

内臓に脂肪がついて生活習慣病の危険性が高まるメタボリックシンドロームの診断について、厚生労働省の研究班は、おなかの周りを測定する現在の方法では、病気に結びつく危険性を女性では5割、男性では7割しか見つけられず、基準の再検討が必要だとする報告をまとめました。

Medical Tribune circulation today 2010.9
循環器疾患版

MonthlyArticle

心血管疾患リスク判定は内臓脂肪CT測定が最良

内臓脂肪蓄積から心血管疾患リスクである点は支持を得たが、正確な内臓脂肪量の測定は腹囲で、ウエスト周囲径以下、腹囲を代用させざるを得ないのが現状だ。日本ではCT測定による内臓脂肪面積と血液因子の関係が検討され、腹囲のカットオフ値が設定された。大規模な疫学研究が行われ、6,000例規模のCT測定に基づく解析が行われ、内臓脂肪面積が心血管疾患の予測に基づくことが示された。国立国際医療研究センター国際保健医療研究部の松下由実室長らの検討で、*Diabetes Care* 2010; 33: 2117-2119)に掲載された。

国際的に不統一な腹囲測定法

メタボリックシンドロームの診断基準では、内臓脂肪蓄積の簡易指標として腹囲が用いられている。しかし、腹囲は測定方法によって誤差が出やすい問題があり、また、その測定部位は国際的にも統一されていないのが現状だ。松下室長らはHitachi Health Studyから行った研究で、世界で使用されている代表的な腹囲の4部位（①臍、②臍と部位の中点③肋骨下縁と前腸骨棘上縁の中点、④最も細い部位）で腹囲を測定し、血圧・脂質・血糖など様々な部位を検討し、*Obesity* 誌に発表した。

この結果、最大値は③④と最小値（①）の差の平均値は男性では3.9cmだったが、女性では12.6cmに及んだ。しかし、リスク重複を予測するには、基本的に③の部位での測定を推奨し、日本のメタボリックシンドロームの診断基準では、内臓脂肪面積100cm²に相当する腹囲部位が男性85cm、女性90cmとして、この値以上の場合

を内臓脂肪蓄積と設定している。メタボリックシンドロームを国際的に比較検討していくためにも、測定部位の国際統一が望まれる。

リスク重複は内臓脂肪面積で最大

Hitachi Health Studyは、厚生労働省研究班として2008年に茨城県日立市の日立製作所日立健康管理センタ放射線画像診断の中川勝主任医長らが開始した共同研究である。今回の解析対象は、2007〜08年に同センターで人間ドックを受けた同社の社員とその配偶者のうち、①26〜75歳②生活習慣病と糖尿病に関する定期検診（OR）の健康診断を受けた6,292例（うち男性5,606例）。職域コホートとして、今後74歳までの追跡が可能である想定のスタディといえる。

CTで測定した内臓脂肪面積と皮下脂肪面積、腹囲、BMIの4つの体格指標について、中性脂肪、HDLコレステロール低値、血圧高値、高血糖のリスクが重複するオッズ比（OR）を算出した。リスク因子については、受診者を各体

格指標の5分位に分け、対象群を調整した。その結果、リスクが2以上に重複するORは、皮下脂肪面積、腹囲、BMIと比較して、内臓脂肪面積で最も高くなった（図）。各体格指標の脂肪面積のORを1とした場合各病群のORは、内臓脂肪面積で男女ともに9を超え、他の指標の1.5〜2の移行に伴いリスクの重複に対するORが顕著に上昇することが示された。一方、腹囲は径時的大に伴うORと上昇が見られるものの、上昇曲線は緩徐で、最大値群はほとんど認められなかった。さらに、腹囲のみでは内臓脂肪が皮下型であるかの区別が困難とされる予定も、あらためて示された。

同疫学試験は、20〜30年間に及ぶ長期追跡が予定されている。経年的な内臓脂肪面積の変化と、心血管疾患リスクの関係も検証される予定だ。

図　心血管疾患リスクファクター重複のオッズ比と実例

Comment

国立国際医療研究センター
国際保健医療研究部
松下由実室長

今回の解析から、CTで測定した内臓脂肪面積は、心血管疾患のリスクファクター重複を予測する指標として優れていることがあらためて実証された。日本は、健康診断と保健指導の制度が整備された世界的にも大きな国であり、メタボリックシンドローム診断における腹囲の基準設定が与える影響は大きい。この

ため、本試験の今後の一連の解析においても、医学的な視点に加え医療経済的な視点からも考慮しなければならない。

現在、内臓脂肪蓄積の簡易指標として用いられている腹囲が、心血管疾患のリスクを正確に反映していないことは本研究でも明らかになった。今後、心血管疾患のリスクをより反映できる指標を模索していきたいと考えている。

（上：*Diabetes Care* 2010; 33: 2117-2119。下：日立健康管理センター提供）