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PAPER

Is adiposity at normal body weight relevant for cardiovascular disease risk?

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OBJECTIVE: To examine the relation between adiposity and risk factors for cardiovascular disease (CVD) in normal weight (NW) individuals.
METHODS: Cross-sectional study using the sample of white people, aged from 17 to 60 y from the Québec Family Study and the Heritage Family Study. NW subjects with a body mass index (BMI) between 18.5 and 25 kg/m^2 (181 males and 265 females) and overweight (OW) subjects with a BMI between 25 and 30 kg/m^2 (133 males and 114 females) were retained for this study. NW subjects were divided into quintiles of each adiposity variable, then the quintiles and the OW group were evaluated for the presence of CVD risk factors. Using logistic regression analysis, the odds ratio (OR) for the prevalence of risk factors for each quintile of each adiposity variable and the OW group was estimated relative to the first quintile in NW subjects. Mean values of adiposity variables were compared between the subjects with and without risk factors. In these analyses, age and study cohort effects were taken into account.
MEASUREMENTS: Percentage body fat (%fat) and fat mass (FM) measured by underwater weighing were available as adiposity variables. Risk factors included systolic and diastolic blood pressure, LDL and HDL cholesterol, triglycerides and fasting glucose.
RESULTS: Wide ranges of values were observed for adiposity variables. HDL cholesterol, triglycerides and fasting glucose in NW males and HDL cholesterol in NW females were significantly correlated with all adiposity variables. For males, higher quintiles of adiposity variables in the NW group and the OW group tended to have higher ORs compared to the first quintiles for the risk factor variables. The fifth quintiles of all adiposity variables had the highest ORs (3.15 for %fat and 3.77 for FM) and they were significantly different from the first quintiles. OW males had ORs similar to those of the fifth quintiles for the risk factor variables. On the other hand, for females, the relatively linear associations were less clear in the NW group. In NW males, the subjects with at least one risk factor had significantly higher %fat and FM than the subjects without risk factors. In NW females, no significant difference was observed for these adiposity variables between the subjects with and without risk factors.
CONCLUSION: NW males with elevated adiposity had higher prevalence of risk factors than NW males with less adiposity and the prevalence in the former was rather similar to that seen in OW males. On the other hand, measures of adiposity added little additional information to the BMI classification of NW on CVD risk factors in females.
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Introduction

Recently, a classification of body weight based on the body mass index (BMI) has been proposed by the World Health Organization (WHO)[1] and adopted by the National Institutes of Health.[2] Overweight (OW) and obesity are defined as a BMI $\geq$ 25 kg/m^2 and a BMI $\geq$ 30 kg/m^2, respectively, while individuals with a BMI of 18.5–24.9 kg/m^2 are identified as normal weight (NW). This classification is based on the apparent risk levels across BMI categories,[3–6] which reveal that individuals with BMI of less than 25 kg/m^2 had lower risk of morbidity or death.

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BMI is a practical indicator of excess body fat, because it is simple, associated with percentage body fat (%fat) and relatively unaffected by body height.[7] However, obesity is theoretically an excess of body fat,[8] and BMI has considerable limitations in predicting %fat for a given individual.[9–11] Using BMI to define OW and obesity, some individuals with above average adiposity are classified as NW, while some individuals without excess body fat, like athletes, are often classified as OW or obese.[12–14]

It has been proposed that subgroups of NW individuals have metabolic disorders comparable to those seen in OW people. Ruderman *et al*[15,16] introduced the concept of the 'metabolically obese, normal-weight individual'. They defined this individual as one who is not obese on the basis of height and weight but is hyperinsulinemic, insulin-resistant and predisposed to type 2 diabetes, hypertriglyceridemic with premature coronary heart disease, and who responds favorably to caloric restriction. Heber *et al*[17] showed that 28 out of 30 NW female subjects with high risk factors had relatively high %fat, as measured by bioelectric impedance. Dvorak *et al*[18] reported that significant differences in %fat, abdominal visceral fat and subcutaneous fat were observed between 13 metabolically obese, NW young females and NW controls. As far as we know, however, no study has been reported on the effect of excess fat in NW individuals, based on large samples of both sexes and using laboratory measures of body composition. The aim of this study was therefore to examine whether NW white people with excess adiposity have higher cardiovascular disease (CVD) risk factors than other NW people with less adiposity or OW people.

Subjects and methods

Subjects

Subjects were Caucasian adults from the Québec Family Study and from the baseline cohort of the HERITAGE Family Study. Detailed information about the Québec Family Study (QFS) and the HERITAGE Family Study is available in prior publications.[19–21] In the HERITAGE Family Study, only healthy sedentary subjects with a systolic blood pressure of less than 160 mmHg and a diastolic blood pressure of less than 100 mmHg, and without significant medical conditions or diseases were included.[20] The sample of the present study included NW subjects with a BMI between 18.5 and 25 kg/m^2 (181 males and 265 females) and OW subjects with a BMI between 25 and 30 kg/m^2 (133 males and 114 females) using the cut-offs proposed by WHO.[1] Only data for the subjects with all measurements of percentage body fat, six skinfold thicknesses and risk factors were retained for the study. The numbers of subjects from the QFS and the HERITAGE Family Study were very similar in each sex and BMI category. Subjects ranged in age from 17 to 60 y. Informed consent was obtained from each subject and the study protocols were approved by the Institutional Review Boards of the QFS and the HERITAGE Family Study centers.

Anthropometric measurements

Anthropometric measurements including stature and body weight were measured according to protocols recommended by the International Biological Program[22] in the QFS and by Lohman *et al*[23,24] in the HERITAGE Family Study. BMI (kg/m^2) was derived as weight in kg/height^2 in meters. Body density was measured by the underwater weighing method in the post-absorptive state.[25] Residual lung volume was measured using the helium dilution technique[26,27] in the QFS and in the Québec clinical center of the HERITAGE Family Study and by the oxygen dilution technique[28,29] in the other centers of the HERITAGE Family Study. The %fat was estimated from body density using the equations of Siri[30] for the sample of the QFS and males from the HERITAGE Family Study, and Lohman[31] for females in the HERITAGE Family Study. Body fat mass (FM) was calculated from %fat and body weight. The underwater weighing method provides a valid estimate of %fat.[32,33]

Blood samples were drawn in the morning after a 12 h fast from an antecubital vein into vacutainer tubes containing ethylenediaminetetraacetic acid. Cholesterol and triglyceride levels were determined in plasma and in lipoprotein fractions by enzymatic methods. Plasma very-low density lipoproteins (density < 1.006 g/ml) were quantitatively isolated by ultracentrifugation,[34] and the high-density lipoprotein (HDL) fraction was obtained after precipitation of low-density lipoprotein (LDL) in the infranatant (density > 1.006 g/ml) with heparin and manganese chloride.[35] Fasting glucose was measured enzymatically.[36] Resting blood pressure measurements were made at least twice in the supine position after at least 5 min of rest. In the QFS, the first measurement was taken with a mercury sphygmomanometer (Baumanometer; WA Baum Co. Inc., Copiague, New York, USA) after 10 min of supine rest, and the second measurement was taken 2 min later.[37] The mean of two consecutive measurements with a difference of less than 10 mmHg was used. Two cuff sizes (9.5 and 13.5 cm) were used, depending on the subject's arm circumference. Systolic blood pressure was determined at the point at which the Korotkoff sound became audible, and diastolic blood pressure was measured at the complete cessation of Korotkoff sounds. In the HERITAGE Family Study, resting blood pressures were measured using Colin STBP-780 automated units (San Antonio, TX, USA) and the recordings were confirmed by technicians wearing ear phones.[20,38] Resting blood pressure was obtained on two separate days before 11:00 am in the post-absorptive state and with no caffeine-containing beverages or tobacco products for at least 2 h before assessment. Measurements were performed in a quiet room at neutral ambient temperature (24–25°C) with the lights dimmed. Subjects rested for 5 min before taking the initial measurement in a reclining chair with legs slightly elevated and back support reclined at about 45° from the ground. Following the rest period, four blood pressure readings were taken at 2 min intervals between measurements. The first recording was discarded automatically, and up to three valid

measurements were made. Systolic and diastolic blood pressure were defined as the means of all valid readings taken on both days. Thus, in the QFS and the HERITAGE Family Study, slightly different procedures were used to measure resting blood pressures. However, the study cohort was taken into account in the analyses to remove sample differences in blood pressure measurements, if there were any.

Statistical analysis

Partial correlation analysis controlling for age and cohort was first used to examine the associations between adiposity variables and risk factors. The NW subjects were also divided into quintiles of %fat and FM. The OW group and each quintile in the NW group were then evaluated for the presence of risk factors. Risk factor classification was based on the following criteria: systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg,[39,40] high LDL cholesterol level (LDL cholesterol ≥ 4.1 mmol/l (160 mg/dl)),[37] low HDL cholesterol level (HDL cholesterol < 0.9 mmol/l (35 mg/dl)),[39] hypertriglyceridemia (TG $\geq$ 2.26 mmol/l (200 mg/dl))[39] and impaired fasting glucose (fasting glucose ≥ 6.1 mmol/l (110 mg/dl)).[41] It is important to recognize that the study is based on a population with a low prevalence of the risk factors since subjects with hypertension, diabetes or taking lipid lowering medications were excluded in the HERITAGE Family Study. Despite the above, 34% of NW males and 16% of NW females had at least one risk factor as defined in this report.

Logistic regression analysis was used to estimate the odds ratios (OR) for prevalence of risk factors across adiposity quintiles of the NW group and in the OW group adjusting for age and study cohort (the QFS and the HERITAGE Family Study). Risk factor status was the dependent variable in the analyses. The lowest quintile of each adiposity variable in the NW group was used as a reference group (OR = 1). The OR was thus determined for each of the other four quintiles in the NW group and for the OW group relative to the first quintile of the NW group for each adiposity variable within each gender. Whether each OR was different from 1 was statistically tested.

The Student *t*-test was used to compare the mean value between the NW and the OW groups. Mean values were compared between the subjects with and without risk factors, using a linear model adjusted for age and cohort. Interaction terms were tested in the models to determine whether the relationship between each adiposity variable and age was different among groups. Less than 20% of the subjects were smokers in these two cohorts. Dietary intake and physical activity levels were assessed in each cohort. However, the procedures used were quite different, which precluded their incorporation into the present series of analyses. Values with $P < 0.05$ (two-tailed tests) were considered significant. All statistical analyses were performed with the SAS statistical package (SAS Institute Inc., Cary, NC, USA).

Results

Physical characteristics of the subjects

Tables 1 (males) and 2 (females) show the mean values, standard deviations and ranges for age, body height and weight and adiposity variables in the NW and the OW groups. Although mean values of age and adiposity variables in the OW group were significantly higher than those in the NW group, very wide ranges for the variables were observed even in the NW group, eg %fat ranged from 0.6 to 35.2% in NW males and from 7.2 to 43.7 % in NW females. The risk factor profiles are shown in Table 3 for males and Table 4 for females. OW subjects had less favorable risk factor profiles than NW subjects in each sex, except for systolic blood pressure in males.

Correlation between body fat and risk factors

Tables 5 (males) and 6 (females) show the correlation coefficients between adiposity variables and risk factors controlled for age and cohort in the NW and the OW groups. In NW males, adiposity variables were significantly correlated with lipid profiles and fasting glucose, especially HDL cholesterol and triglycerides, while there was no significant correlation with blood pressure. Correlations between adiposity variables and risk factors were weak in both NW and OW females. Only HDL cholesterol showed significant correlations with all adiposity variables.

Table 1 Physical characteristics of the male subjects

	NW group (n = *181*)		*OW group* (n = *133*)	
Variables	*Mean (s.d.)*	*Range*	*Mean (s.d.)*	*Range*
Age (y)	29.9 (12.4)	17.0 – 60.0	40.3 (13.4)***	17.2 – 59.5
Height (cm)	176.2 (6.7)	157.2 – 196.8	175.3 (6.8)	158.2 – 189.0
Body weight (kg)	70.0 (7.3)	51.5 – 88.1	82.7 (8.1)***	65.0 – 103.3
BMI (kg/m^2)	22.5 (1.8)	18.6 – 25.0	26.9 (1.4)***	25.0 – 30.0
%fat (%)	15.5 (6.4)	0.6 – 35.2	24.2 (5.4)***	11.2 – 37.0
FM (kg)	11.0 (4.9)	0.3 – 28.2	20.1 (5.5)***	9.4 – 37.1

NW, normal-weight; OW, overweight; BMI, body mass index, %fat, percentage body fat; FM, fat mass.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, between NW group and OW group.

Table 2 Physical characteristics of the female subjects

	NW group (n = *265*)		*OW group* (n = *114*)	
Variables	*Mean (s.d.)*	*Range*	*Mean (s.d.)*	*Range*
Age (y)	32.2 (12.5)	17.2 – 59.5	39.3 (13.1)***	17.0 – 59.7
Height (cm)	162.6 (6.1)	140.7 – 176.7	162.2 (7.0)	142.7 – 178.0
Body weight (kg)	58.1 (6.0)	45.3 – 74.8	71.0 (7.1)***	54.7 – 90.3
BMI (kg/m^2)	22.0 (1.7)	18.5 – 25.0	26.9 (1.4)***	25.0 – 30.0
%fat (%)	24.8 (6.1)	7.2 – 43.7	34.9 (4.9)***	24.9 – 50.1
FM (kg)	14.6 (4.5)	3.3 – 30.4	24.8 (4.6)***	16.6 – 37.8

NW, normal-weight; OW, overweight; BMI, body mass index; %fat, percentage body fat; FM, fat mass.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, between NW group and OW group.

Table 3 Risk factor profiles of the male subjects

	NW group (n = *181*)		*OW group* (n = *133*)	
Risk factors	*Mean (s.d.)*	*Range*	*Mean (s.d.)*	*Range*
Systolic blood pressure (mmHg)	115.5 (11.2)	84.0 – 153.0	117.2 (10.1)	92.0 – 149.0
Diastolic blood pressure (mmHg)	67.3 (8.8)	44.7 – 98.0	70.6 (9.7)**	44.5 – 93.5
LDL cholesterol (mmol/l)	2.82 (0.84)	0.92 – 6.02	3.31 (0.80)***	1.15 – 5.72
HDL cholesterol (mmol/l)	1.09 (0.23)	0.65 – 1.90	1.01 (0.25)**	0.57 – 1.85
Triglycerides (mmol/l)	1.14 (0.61)	0.38 – 3.66	1.61 (0.71)***	0.51 – 4.55
Fasting glucose (mmol/l)	4.98 (0.42)	4.10 – 6.75	5.28 (0.55)***	4.15 – 7.50

NW, normal-weight; OW, overweight.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, between NW group and OW group.

Table 4 Risk factor profiles of the female subjects

	NW group (n = *265*)		*OW group* (n = *114*)	
Risk factors	*Mean (s.d.)*	*Range*	*Mean (s.d.)*	*Range*
Systolic blood pressure (mmHg)	110.6 (11.3)	88.0 – 170.0	113.5 (11.3)*	85.7 – 148.0
Diastolic blood pressure (mmHg)	64.9 (8.5)	43.5 – 95.0	68.0 (8.7)**	45.5 – 91.0
LDL cholesterol (mmol/l)	2.74 (0.74)	0.73 – 5.59	3.12 (0.87)***	1.16 – 6.29
HDL cholesterol (mmol/l)	1.32 (0.32)	0.54 – 2.26	1.23 (0.33)*	0.72 – 2.34
Triglycerides (mmol/l)	1.10 (0.49)	0.38 – 3.34	1.28 (0.52)**	0.52 – 3.66
Fasting glucose (mmol/l)	4.80 (0.37)	3.75 – 6.25	5.05 (0.76)***	3.95 – 11.55

NW, normal-weight; OW, overweight.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, between NW group and OW group.

Table 5 Partial correlation coefficients between adiposity variables and risk factors controlled for age and study cohort in males

	NW group (n = *181*)		*OW group* (n = *133*)	
Risk factors	*%fat*	*FM*	*%fat*	*FM*
Systolic blood pressure	0.05	0.04	− 0.01	0.02
Diastolic blood pressure	0.13	0.12	− 0.03	− 0.05
LDL cholesterol	0.21**	0.18*	0.19*	0.23**
HDL cholesterol	− 0.24**	− 0.24**	− 0.08	− 0.10
Triglycerides	0.34***	0.30***	0.14	0.16
Fasting glucose	0.17*	0.18*	0.10	0.14

NW, normal-weight; OW, overweight; %fat, percentage body fat; FM, fat mass.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 6 Partial correlation coefficients between adiposity variables and risk factors controlled for age and study cohort in females

	NW group (n = *265*)		*OW group* (n = *114*)	
Risk factors	*%fat*	*FM*	*%fat*	*FM*
Systolic blood pressure	0.09	0.08	0.02	0.07
Diastolic blood pressure	0.15*	0.13*	0.10	0.06
LDL cholesterol	0.04	0.04	0.13	0.14
HDL cholesterol	− 0.18**	− 0.20**	− 0.01	− 0.09
Triglycerides	0.05	0.07	− 0.14	− 0.07
Fasting glucose	0.07	0.13*	− 0.06	− 0.04

NW, normal-weight; OW, overweight; %fat, percentage body fat; FM, fat mass.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Comparison of risk factor variables among quintiles of adiposity

The NW subjects were divided into quintiles for each adiposity variable. The subjects in the highest quintile of %fat had a %fat of 21.1% or more and 30.7% or more in NW males and females, respectively. The highest prevalence of any risk factor was observed for HDL cholesterol in both sexes among NW subjects (22.1% in NW males and 8.3% in NW females), while prevalence of the subjects who had higher fasting glucose than the criterion was very low, 1.6% in NW males and 0.4% in NW females. The age and study cohort-adjusted ORs for having at least one CVD risk factor for each adiposity variable in the OW group and quintiles of the NW group are presented in Tables 7 and 8. For males, higher quintiles of adiposity variables in the NW group and the OW group tended to have higher ORs, except for the third quintiles. The fifth quintiles of all adiposity variables had the highest ORs (3.15 for %fat and 3.77 for FM) among the quintiles in the NW group, the ORs being significantly higher relative to the first quintiles. OW males had ORs similar to those of the fifth quintiles for all adiposity variables. In females, the OW group had the highest ORs which were significantly higher relative to the first quintiles for all adiposity variables. Among the NW group, only the second and third quintiles of FM had significantly higher ORs relative to the first quintile.

Comparison of adiposity variables between the subjects with and without risk factors

Mean values for adiposity variables adjusted for age and study cohort were compared between the subjects with risk factors and the subjects without risk factors in NW group for each sex (Tables 9 and 10). Because no interaction terms were significant, they were excluded from the models. In NW males, subjects with at least one risk factor had significantly higher %fat and FM than subjects without risk factors, while there was no significant difference in BMI. In NW females, no significant differences were observed.

Table 9 Comparison of age- and study-cohort-adjusted mean of adiposity variables between the subjects with and without risk factors in NW males

Variables	*Subjects without risk factor (n = 120) Mean (standard error)*	*Subjects with risk factors (n = 61) Mean (standard error)*
BMI (kg/m^2)	22.3 (0.2)	22.7 (0.2)
%fat (%)	14.9 (0.5)	16.8 (0.7)*
FM (kg)	10.5 (0.4)	12.0 (0.6)*

NW, normal-weight; BMI, body mass index; %fat, percentage body fat; FM, fat mass.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, between subjects with and without risk factors.

Table 7 ORs of prevalence of risk factors adjusted for age and study cohort in males

		NW group					
No. of quintiles		*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*OW group*
Quintiles of %fat	Range of %fat	0.6–10.4	10.5–13.6	13.8–16.9	17.1–20.9	21.1–35.2	11.2–37.0
	Number of subjects[a]	7/36	12/36	6/37	16/35	20/37	77/133
	OR	1	1.94	0.67	2.65	3.15*	3.46*
Quintiles of FM	Range of FM	0.3–6.6	6.7–9.3	9.4–12.3	12.5–15.2	15.4–28.2	9.4–37.1
	Number of subjects[a]	6/36	13/36	6/37	16/36	20/36	77/133
	OR	1	2.42	0.74	2.86	3.77*	3.93**

OR (odds ratio), relative to the first quintile in NW group, obtained by logistic regression analysis adjusting for age and study cohort.
NW, normal-weight; OW, overweight; %fat, percentage body fat; FM, fat mass.
[a]Number of subjects with at least one risk factor/total number of subjects in each quintile.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, significantly different from 1.

Table 8 ORs of prevalence of risk factors adjusted for age and study cohort in females

		NW group					
No. of quintiles		*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*OW group*
Quintiles of %fat	Range of %fat	7.2–19.6	19.7–22.9	23.1–26.3	26.4–30.4	30.7–43.7	24.9–50.1
	Number of subjects[a]	4/52	8/54	11/54	11/51	8/54	37/114
	OR	1	1.92	2.88	3.00	1.66	4.74**
Quintiles of FM	Range of FM	3.3–10.7	10.8–12.9	12.9–15.4	15.4–18.9	19.0–30.4	16.6–37.8
	Number of subjects[a]	2/53	10/53	12/53	9/53	9/53	37/114
	OR	1	5.64*	7.28*	4.67	4.41	10.31**

OR (odds ratio), relative to the first quintile in NW group, obtained by logistic regression analysis adjusting for age and study cohort.
NW, normal-weight; OW, overweight; %fat, percentage body fat; FM, fat mass.
[a]Number of subjects with at least one risk factor/total number of subjects in each quintile.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, significantly different from 1.

Table 10 Comparison of age- and study-cohort-adjusted mean of adiposity variables between the subjects with and without risk factors in NW females

Variables	*Subjects without risk factor (n = 223) Mean (standard error)*	*Subjects with risk factors (n = 42) Mean (standard error)*
BMI (kg/m^2)	21.9 (0.1)	22.1 (0.3)
%fat (%)	24.7 (0.4)	25.5 (0.9)
FM (kg)	14.5 (0.3)	15.2 (0.7)

NW, normal-weight; BMI, body mass index; %fat, percentage body fat; FM, fat mass.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, between subjects with and without risk factors.

Discussion

Even among the NW subjects, wide ranges were observed for adiposity variables, and the issue was whether this variability was associated with the prevalence of risk factors. Adiposity variables were significantly correlated with the lipid profile and fasting glucose in NW males. On the other hand, only a few significant correlations, including some with HDL cholesterol, were observed in NW females. The fifth quintiles in NW males had more than three times (OR = 3.15 for %fat and 3.77 for FM) the prevalence of CVD risk factors compared to the first quintiles of adiposity variables in NW males and had a prevalence similar to that of OW males. For females, the linear associations were less clear in the NW group, while the OW group had the highest prevalence of risk factors. These results imply that measures of adiposity carry additional information for CVD risks in NW males, as defined by BMI. In contrast, the BMI classification of NW without measures of adiposity may be acceptable for CVD risk factors in NW females.

One of the possible reasons for the sex difference may be the effect of estrogen on CVD risk factors,[42–44] ie the protective effects of estrogen on plasma lipids may be stronger than the variability in adiposity. Another possible reason is the sex difference in the biology of lower body fat. It has been shown that thigh fat is associated with higher plasma HDL cholesterol levels[45–47] and a lower incidence of diabetes only in females.[48] Most women have a gynoid profile of fat deposition with more adiposity in lower body segment.[49] However, the present study examined the association between the presence of risk factors and total adiposity but not body fat distribution. Variation in abdominal fat may explain the fact there was almost no difference across adiposity quintiles among NW females, as Ruderman *et al*[16] suggested.

A few other studies have examined the relationship between %fat and metabolic disorders in NW subjects, but the numbers of subjects in these studies were much smaller. Heber *et al*[17] and Dvorak *et al*[18] showed that nonobese women seen in the UCLA Breast Center's High Risk Clinic and young women with impaired insulin sensitivity had higher %fat. In contrast, our study could not detect a difference in adiposity variables between women with and without CVD risk factors. Heber *et al*[17] used the single frequency bioelectric impedance method to estimate %fat, a method which has less accuracy than other techniques.[50] On the other hand, Dvorak *et al*[18] defined 'metabolically obese, normal-weight' subjects based on insulin sensitivity, as proposed by Ruderman *et al*.[15,16] Insulin resistance is potentially related to several metabolic disorders such as those commonly observed in the metabolic syndrome.[51–53] However, it is likely that individuals with insulin resistance and those with CVD risk factors used in the present study have different adiposity characteristics. In the present study, the highest prevalence of risk factor was observed for HDL cholesterol in both sexes among NW subjects (22.1% in NW males and 8.3% in NW females), while prevalence of the subjects who had higher fasting glucose than the criterion was very low, 1.6% in NW males and 0.4% in NW females. On the other hand, Dvorak *et al*[18] reported that there was no significant difference in blood pressure and lipids between metabolically obese, a NW group and a control group.

In the present study, quintiles were used to divide NW subjects. The NW males and females in the fifth quintile of %fat had values of 21.1% or more and 30.7% or more, respectively. These values are almost identified to the criteria used previously to define obesity from %fat,[54,55] that is, 20% for males and 30% for females. The cut-off value of 30% for females is also the value Dvorak *et al*[18] proposed based on their results. Such standards or recommendations have obvious limitations since they are strongly influenced by the method used to assess adiposity, are generally derived from limited sample sizes, and are set arbitrarily.

The results of the present study are possibly applicable only to individuals of Caucasian ancestry. Ko *et al*[56] indicated that the risk of metabolic disorders begins to increase at a BMI of about 23 kg/m^2 in a study of Hong Kong Chinese. Hence, specific cut-off BMI values of 23.0 for 'at risk' and 25.0 for 'obese' have been proposed recently for people of the Asian-Pacific region.[57] Fujimoto *et al*[58] suggested that the susceptibility to CVD is particularly high in Japanese Americans, due to a predisposition to gain weight, possibly leading to a larger accumulation of abdominal visceral fat. In addition, a meta analysis by Deurenberg *et al*[59] revealed that Asian people have a lower BMI for the same level of body fat compared to white people. Therefore, ethnic differences in body composition and susceptibility to CVD should be taken into account when interpreting the results of the present study.

In conclusion, in males, the prevalence of CVD risk factors in NW individuals with high adiposity was higher than in NW individuals with low adiposity and similar to that in OW individuals. On the other hand, NW females with more adiposity did not have a higher prevalence of risk factors than the other NW females.

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