METABOLIC FEATURES BY TYPE OF OBESITY, BASED ON BODY MASS INDEX AND WAIST TO HIP CIRCUMFERENCE RATIO IN JAPANESE WOMEN

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Abstract

In 176 Japanese women aged 20~79, participating in a health assessment programme, we studied the associations between several metabolic features and the type of obesity based on body mass index and waist to hip circumference ratio. We propose the existence of three types of obesity based on BMI and WHR: Type-I, obese women who have a high BMI and a low WHR, Type-II, obese women who have a low BMI and a high WHR, and Type-III, obese women who have both a high BMI and a high WHR. Age was categorized into three levels for all analyses (≤ 49 , 50 - 59, and ≥ 60 yr). There was no significant association of WHR with any metabolic variable after adjustment for the effects of the BMI in any group. The results of the present study show that the amount of body fat is in itself more important than the WHR. Where p values were significant, levels of metabolic risk factors for disease increased across the tertiles composed from a combination of the BMI and WHR, except for HDL-ch and HDL-ch/T-ch, where levels fell. Although the means of these metabolic parameters in each type of obesity were all within the normal range, significant differences were observed between the group with Type-III obesity and the nonobese group for these parameters.

In conclusion, the most "dangerous" subgroup of obesity appeared to be Type-III obesity in which high levels of BMI and WHR coexist.

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key words: Body mass index, Waist-to-hip ratio, Type of obesity, Lipid and lipoprotein, Blood pressure, Dangerous subgroup of obesity

I. Introduction

Obesity has been generally defined as excessive storage of energy in the form of fat. Excess body weight, or more specifically excess body fat, influences the health risk profile and increases mortality and morbidity^{14,34)}. Obesity is, however, a heterogeneous condition in terms of the topographical distribution of fat in each subject. The topography of body fat in humans has attracted the attention of obesity scientists and clinicians because of the apparent metabolic complications associated with excessive abdominal fat.

Vague^{40,41)} was the first to point out that "android" or centralised obesity was more closely

associated with diabetes, gout, and atherosclerosis than the more peripheral fat distribution associated with "gynaecoid" obesity. Recently, experimental and clinical observations have suggested that intra-abdominal visceral fat, particularly in the fat depots draining into the hepatic portal circulation, correlate best with of metabolic complications related to body fat distribution^{4,5,9,20)}. At this time, abdominal visceral fat is best assessed with computed tomography (CT). The distinction between "portal" and "nonportal" fat tissues is not, however, easily made with this technique.

Whereas anthropometry may be used to assess the relative distribution of fat in large numbers of

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patients, this is obviously not feasible with CT. The most popular anthropometric variable for describing body fat distribution is the ratio of waist-to-hip circumference (WHR). The WHR is positively correlated with the amount of visceral fat^{26,30)}, which is in turn associated with hyperinsulinemia, insulin resistance, and high free fatty acid levels, and thereby with impairment of glucose tolerance^{7,11,27,29,31)}, hypertension^{28,30)}, and high triglyceride (TG) and low HDL-cholesterol (HDL-ch) levels^{5,8,9,36)}.

According to various studies, the body mass index (BMI) appears to be a reasonably good index of adiposity in adults^{2,12,18)}. Moreover, several studies have demonstrated that BMI and age are, in addition to gender, the most important variables that affect body fat distribution^{13,17,22,33,38,39)}. Previous studies have also suggested that the prevalence of hypertension, hyperlipidemia and hyperuricemia increase with the BMI^{15,25,37)}. However, the BMI does not take into account frame size or variation in the body fat pattern, both of which may be related to the health risk

profile.

Abdominal obesity and peripheral obesity are the two representative categories into which obesity is currently classified. The frequencies of metabolic complications, including glucose intolerance and hyperlipidemia, have been shown to be quite different between these two types of obesity. We propose the existence of three types of obesity: Type-I obesity, characterized by a pronounced accumulation of subcutaneous fat, Type-II obesity, characterized by fat accumulation mainly in the abdominal cavity, and Type-III obesity, characterized by a pronounced accumulation of both abdominal and subcutaneous fat.

In this study the association of these three types of obesity with metabolic features was examined in a group of Japanese women.

II. Materials and methods

A. Subjects

The subjects of this study were 176 female volunteers referred to the Institute of Health Science at Kyushu University for health assessment.

Table 1. Means and standard deviations for descriptive variables in 176 women.

	≤ 49yr n=68	50 - 59yr n=59	60yr ≤ n=49	p	Total N=176
Age, yr	41.1 ± 7.4	54.1 ± 3.0	64.5 ± 4.0	***	52.0 ± 10.9
Height, cm	155.0 ± 4.3	152.0 ± 6.1	151.7 ± 5.1	***	153.1 ± 5.4
Weight, kg	59.97 ± 8.92	57.80 ± 7.46	53.83 ± 7.19	***	57.53 ± 8.32
Body Mass Index, kg/m ²	24.92 ± 3.71	25.08 ± 3.35	23.37 ± 2.70	*	24.53 ± 3.8
Abdominal circumference, cm	80.9 ± 9.8	82.5 ± 9.9	80.7 ± 8.8	n.s	81.4 ± 9.6
Hip circumference, cm	91.0 ± 5.5	89.3 ± 4.1	87.6 ± 4.2	***	89.5 ± 4.9
Waist-to-Hip Ratio	0.886 ± 0.071	0.921 ± 0.080	0.919 ± 0.071	*	0.907 ± 0.076
Triceps skinfold, mm	19.1 ± 4.9	19.2 ± 5.7	18.1 ± 4.5	n.s	18.8 ± 5.1
Sub-scapular skinfold, mm	24.5 ± 8.4	24.3 ± 8.5	20.6 ± 6.5	*	23.4 ± 8.1
Total-cholesterol, mg/dl	203 ± 34.2	220 ± 34.0	224 ± 27.6	**	215 ± 33.5
HDL-cholesterol, mg/dl	59 ± 14.9	58 ± 14.9	61 ± 14.2	n.s	59 ± 14.7
HDL/T-ch.	0.30 ± 0.09	0.27 ± 0.07	0.28 ± 0.07	n.s	0.28 ± 0.08
LDL-cholesterol, mg/dl	127 ± 34.5	142 ± 31.7	142 ± 27.4	**	136 ± 32.4
Triglyceride, mg/dl	86 ± 40.8	98 ± 46.1	100 ± 61.8	n.s	94 ± 49.3
Glucose, mg/dl	93 ± 13.6	91 ± 9.2	92 ± 9.8	n.s	92 ± 11.2
Systolic blood pressure, mmHg	116 ± 15.0	123 ± 16.3	129 ± 15.6	***	121 ± 16.4
Diastolic blood pressure, mmHg	67 ± 9.8	68 ± 9.9	72 ± 9.8	*	69 ± 10.0

P values were calculated using one-way analysis of variance, n. s.; non-significant, *; $p < 0.05$, **; $p < 0.01$, ***; $p < 0.001$.

The volunteers ranged in age from 20 to 79 yrs, and had no known diabetes mellitus, other endocrine disorders or cardiovascular disease. The purpose of the investigation was fully explained to each participant, and all gave written informed consent before commencing the study. This population included subjects with a wide range of BMI (from 15.85 to 32.56 kg/m²) and WHR (from 0.685 to 1.074). Their physical characteristics are summarized in Table 1.

B. Anthropometry

The waist and hip circumferences, triceps and sub-scapular skinfold thicknesses, body weight, and height were picked out as anthropometric measures. Body weight and height were measured in subjects wearing light clothing without shoes. The BMI was calculated from the formula weight/height² (kg/m²). Waist circumference (cm) was measured at the level of the umbilicus, and hip circumference at the position of its largest, while the subject breathed normally. An inelastic tape was used for circumference measurements, and the skin was not compressed. In an attempt to determine the predictive power of abdominal adipose tissue distribution the WHR was calculated. A Harpenden calliper was used for skinfold thickness measurements. The subject stood erect during all measurements. All anthropometric measurements were performed by a single observer.

C. Metabolic parameters

Blood samples were obtained from each subject after an overnight fast. Serum total cholesterol (T-ch) and triglyceride (TG) levels were determined by enzymatic methods. Serum HDL-ch was measured by a precipitation method. Plasma glucose (GL) was measured by the glucose oxidase method. All biochemical analyses were performed at Creative Research Community, Inc., Fukuoka. The very-low-density lipoprotein cholesterol (VLDL-ch) and low-density lipoprotein chole-

sterol (LDL-ch) values were calculated using the equations of Friedewald et al.¹⁰⁾, where VLDL-ch = TG/5 and LDL-ch = T-ch - (HDL-ch + VLDL-ch). The ratio of HDL-ch to T-ch, which has been proposed to be the best predictor of coronary artery disease⁶⁾, was used in this study. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured three times in the right arm over a period of 10 min with the subject seated, using an automatic sphygmomanometer (BP-203 NP, NIPPON COLIN Co., Ltd., Tokyo). The mean value of the three blood pressure readings was used in subsequent analyses.

D. Statistical analysis

Age was categorized into three levels for all analyses (20 ~ 49, 50 ~ 59, and 60 ~ 79 yr). The cut-off points for each metabolic variable were determined based on the following abnormal ranges - ≥ 220 mg/d l (T-ch), ≤ 40 mg/d l (HDL-ch), ≤ 0.18 (HDL-ch/T-ch), ≥ 150 mg/d l (LDL-ch), ≥ 150 mg/d l (TG), ≥ 110 mg/d l (GL), ≥ 140 mmHg (SBP) and ≥ 85 mmHg (DBP). Tertiles for BMI and WHR distribution were determined from the mean value in sample women with metabolic parameter values higher or lower than the cut-off points for each metabolic variable. Thereafter, the obese women were divided into three groups according to these BMI and WHR tertiles (Table 5, 6, and 7). Results are presented as mean $\pm$ standard deviation. Data were analysed using correlation coefficients and partial correlation coefficients. Adjustments for BMI or WHR were made by partial correlation. Differences with *p* values below 0.05 were regarded as statistically significant.

III. Results

The relationships between the BMI and WHR and the metabolic variables are shown in Table 2. The T-ch concentration was not significantly correlated with BMI or WHR. Furthermore, with

Table 2. Significant Pearson's correlation coefficients between metabolic features and BMI, and WHR.

	BMI			WHR		
	≤49yr	50 - 59yr	60yr≤	≤49yr	50 - 59yr	60yr≤
T-ch.	-	-	-	-	-	-
HDL-ch.	-0.520***	-0.383**	-0.419**	-0.445***	-0.428***	-0.296*
HDL-ch./T-ch.	-0.591***	-0.264*	-0.380**	-0.495***	-0.345**	-0.325*
LDL-ch.	0.332**	-	-	-	-	-
TG	0.279*	-	0.527***	0.291*	0.280*	-
GL	0.393***	-	-	-	0.295*	-
SBP	-	0.437***	-	0.265*	0.465***	-
DBP	-	0.422***	-	-	0.496***	-

- ; non-significant, * ; $p < 0.05$, ** ; $p < 0.01$, *** ; $p < 0.001$.

the exception of BMI in the group aged 49 and below, the LDL-ch concentration was not associated with BMI or WHR. The HDL-ch and HDL-ch/T-ch concentrations were significantly and negatively correlated with BMI and WHR, whereas TG, GL, SBP and DBP were positively correlated with these variables.

Figure 1 shows the relationship between the BMI and WHR. The correlation coefficient between the BMI and WHR was significant ($p < 0.001$) in each group. Because the BMI and WHR were significantly correlated, partial correlation analyses were used to determine how much the BMI and WHR correlate independently with the metabolic variables.

Table 3 shows the significant partial correlation of the BMI with each metabolic variable with the WHR partialled out, and for the WHR and each metabolic variable with the BMI partialled out. The BMI remained with WHR partialled out significantly related to HDL-ch, HDL-ch/T-ch, LDL-ch and GL in the group aged 49 and below. There was no significant association of WHR with any metabolic variable with the effects of the BMI partialled out in any group.

To investigate the pathogenic relationships of the metabolic factors to the type of obesity, we calculated the levels of BMI and WHR in a sample of patients with metabolic variable values higher

Fig. 1. Scatterplots showing correlation between the body mass index (BMI) and waist-to-hip circumference ratio (WHR) in female subjects.

or lower than the cut-off point. The results are presented in Table 4. We defined the cut-off points for the BMI tertiles in each metabolic variable group as 27.28, 26.92, and 26.23 kg/m^2 , respectively. For WHR, cut-off points were 0.929, 0.975, and 0.950, respectively.

The means for the various metabolic variables

Table 3. Significant relationship of the WHR and BMI to metabolic features after controlling for each WHR and BMI in female subjects.

Dependent variable;	Controlling for:					
	WHR		BMI		WHR	
	≤49yr		50 - 59yr		60yr≤	
	BMI	WHR	BMI	WHR	BMI	WHR
HDL-ch.	-0.316**	-	-	-	-0.312*	-
HDL-ch./T-ch.	-0.383**	-	-	-	-	-
LDL-ch.	0.264*	-	x	x	x	x
TG	-	-	-	-	0.497***	-
GL	0.383**	-	-	-	x	x
SBP	-	-	-	-	x	x
DBP	x	x	-	0.290*	x	x

- ; non-significant, * ; $p < 0.05$, ** ; $p < 0.01$, *** ; $p < 0.001$.

Table 4. Means and standard deviations of BMI and WHR on the cut-off points for each metabolic variable.

	n	≤49yr		n	50 - 59yr		n	60yr≤	
		BMI	WHR		BMI	WHR		BMI	WHR
HDL-ch.	4	28.74±1.10	0.952±0.029	5	26.24±1.04	0.988±0.025	2	26.30±2.24	0.919±0.036
HDL-ch./T-ch.	3	28.57±1.07	0.976±0.003	6	27.19±2.17	0.988±0.043	3	24.52±3.38	0.942±0.084
LDL-ch.	19	26.46±2.90	0.912±0.072						
TG	6	25.77±3.19	0.940±0.045	9	26.52±2.49	0.959±0.064	7	26.95±2.18	0.962±0.071
GL	6	29.10±2.04	0.913±0.043	4	25.96±1.81	0.955±0.046			
SBP	6	27.96±4.31	0.953±0.069	10	27.68±2.18	0.984±0.050			
DBP				2	27.73±1.06	0.980±0.049			
Total	44	27.28±2.99	0.929±0.061	36	26.92±2.04	0.975±0.049	12	26.23±2.50	0.950±0.067

cut-off points ; T-ch. ≥ 220 mg/dℓ, HDL-ch. ≤ 40 mg/dℓ, HDL-ch./T-ch. ≤ 0.18 , LDL-ch. ≥ 150 mg/dℓ, TG ≥ 150 mg/dℓ, GL ≥ 110 mg/dℓ, SBP ≥ 140 mmHg, DBP ≥ 85 mmHg.

were calculated across the tertiles of a combination of the BMI and WHR for the three age groups separately, as shown in Tables 5, 6, and 7. Levels

of all risk factors varied significantly across the tertiles in the group aged 60 and over, and all factors except LDL-ch and SBP varied significantly

Table 5. Means of metabolic features by the type of obesity in female subjects aged 49 and below.

	Normal	Type-I	Type-II		Type-III		p
	n=42	n=9	n=6	n=6	n=11	n=11	
BMI	22.76 ± 2.80	29.02 ± 1.32 ***	25.98 ± 1.23 **	25.98 ± 1.23 **	29.26 ± 1.42 ***	29.26 ± 1.42 ***	***
WHR	0.847 ± 0.057	0.912 ± 0.023**	0.977 ± 0.029***	0.977 ± 0.029***	0.968 ± 0.027***	0.968 ± 0.027***	***
HDL-ch.	64 ± 14.4	52 ± 12.6 *	56 ± 8.7 n.s	56 ± 8.7 n.s	48 ± 13.8 **	48 ± 13.8 **	**
HDL-ch./T-ch.	0.32 ± 0.09	0.27 ± 0.06 n.s.	0.27 ± 0.06 n.s	0.27 ± 0.06 n.s	0.24 ± 0.06 **	0.24 ± 0.06 **	**
LDL-ch.	123 ± 35.7	128 ± 39.9 n.s	142 ± 29.0 n.s	142 ± 29.0 n.s	133 ± 28.2 n.s	133 ± 28.2 n.s	n.s
TG	79 ± 35.9	93 ± 37.7 n.s	72 ± 48.0 n.s	72 ± 48.0 n.s	115 ± 47.6 **	115 ± 47.6 **	*
GL	90 ± 12.7	96 ± 14.8 n.s	87 ± 12.2 n.s	87 ± 12.2 n.s	102 ± 12.5 **	102 ± 12.5 **	*
SBP	113 ± 13.0	112 ± 13.8 n.s	119 ± 7.1 n.s	119 ± 7.1 n.s	126 ± 22.0 n.s	126 ± 22.0 n.s	n.s

Normal ; BMI < 27.28 : WHR < 0.929 , Type- I ; BMI ≥ 27.28 : WHR < 0.929 , Type- II ; BMI < 27.28 : WHR ≥ 0.929 , Type- III ; BMI ≥ 27.28 : WHR ≥ 0.929 , T values were calculated between normal and each type of obesity using unpaired Student's t test. P values were calculated using one-way analysis of variance, n. s ; non-significant, * ; $p < 0.05$, ** ; $p < 0.01$, *** ; $p < 0.001$.

Table 6. Means of metabolic features by the type of obesity in female subjects aged from 50 to 59 years.

	Normal n=33	Type-I n=9	t	Type-II n=5	t	Type-III n=12	t	p
BMI	22.84 ± 2.39	28.10 ± 0.85 ***		25.15 ± 1.33 *		28.95 ± 1.59 ***		***
WHR	0.869 ± 0.057	0.936 ± 0.029**		1.003 ± 0.010***		1.020 ± 0.032***		***
HDL-ch.	63 ± 14.7	55 ± 9.3 n.s.		47 ± 27.9 n.s.		47 ± 11.7 **		**
HDL-ch./T-ch.	0.28 ± 0.07	0.28 ± 0.07 n.s.		0.26 ± 0.10 n.s.		0.22 ± 0.06 *		n.s.
TG	87 ± 44.0	86 ± 36.0 n.s.		116 ± 42.9 n.s.		128 ± 48.1 *		*
GL	88 ± 9.5	93 ± 9.4 n.s.		93 ± 6.9 n.s.		95 ± 7.8 *		n.s.
SBP	119 ± 16.1	119 ± 13.7 n.s.		127 ± 14.9 n.s.		132 ± 16.4 *		n.s.
DBP	66 ± 10.1	67 ± 8.8 n.s.		74 ± 9.9 n.s.		74 ± 8.1 *		n.s.

Normal; BMI < 26.92; WHR < 0.975, Type-I; BMI ≥ 26.92; WHR < 0.975, Type-II; BMI < 26.92; WHR ≥ 0.975, Type-III; BMI ≥ 26.92; WHR ≥ 0.975, T values were calculated between normal and each type of obesity using unpaired Student's t test, P values were calculated using one-way analysis of variance, n.s.; non-significant, *; p < 0.05, **; p < 0.01, ***; p < 0.001.

Table 7. Means of metabolic features by the type of obesity in female subjects aged 60 and over.

	Normal n=30	Type-I n=2	t	Type-II n=12	t	Type-III n=5	t	p
BMI	21.92 ± 1.68	27.74 ± 0.20		24.12 ± 1.58 ***		28.49 ± 0.68 ***		***
WHR	0.875 ± 0.045	0.915 ± 0.031		0.990 ± 0.040***		1.013 ± 0.034***		***
HDL-ch.	64 ± 13.7	42 ± 10.6		63 ± 13.5 n.s.		48 ± 4.1 *		*
HDL-ch./T-ch.	0.29 ± 0.07	0.17 ± 0.04		0.28 ± 0.05 n.s.		0.23 ± 0.04 n.s.		*
TG	83 ± 41.3	295 ± 58.0		86 ± 26.1 n.s.		159 ± 66.6 **		***

Normal; BMI < 26.23; WHR < 0.950, Type-I; BMI ≥ 26.23; WHR < 0.950, Type-II; BMI < 26.23; WHR ≥ 0.950, Type-III; BMI ≥ 26.23; WHR ≥ 0.950, T values were calculated between normal and each type of obesity using unpaired Student's t test, P values were calculated using one-way analysis of variance, n.s.; non-significant, *; p < 0.05, **; p < 0.01, ***; p < 0.001.

across the tertiles in the group aged 49 and below. The BMI and WHR tertiles were related to fewer variables in the group aged between 50 and 59 yr, with only HDL-ch and TG varying significantly across the tertiles. Where p values were significant, levels of risk factors increased across the tertiles, except for HDL-ch and HDL-ch/T-ch, where levels fell. However, the obese women with high levels of BMI and low levels of WHR (Type-I) did not differ significantly from the nonobese groups, except in the group aged 60 and over (n = 2). Moreover, no significant differences were seen between the obese women who had a low levels of BMI and high levels of WHR (Type-II) and the nonobese group in any age

group. Although the mean values, of these metabolic parameters in each type of obesity were all within the normal range, significant differences were observed between obese women with high levels of BMI and WHR (Type-III) and the nonobese group in these parameters. Consequently, the most "dangerous" subgroup of obesity appeared to be Type-III obesity, the levels of both BMI and WHR were high.

IV. Discussion and conclusion

In the developed countries, overeating and decreased muscular exercise are responsible for the increasing incidence of various types of obesity. Previous studies have generally demonstrated

only small degrees of correlation between increased body fat and either serum T-ch or TG levels^{16,24}). It has been established that obesity is an independent risk factor for cardiovascular disease¹⁴). Obesity is, however, associated with several cardiovascular risk factors; elevated T-ch¹) and TG levels^{1,3}), reduced HDL-ch levels¹), hypertension³⁵), and noninsulin-dependent diabetes²³). Although obesity itself may not be a major determinant of blood lipid levels, adipose tissue distribution appears to contribute independently to the level of TG. Scientific assessment in recent years has revealed that morbidity and mortality in obese subjects are closely related to regional body fat distribution.

Obesity has been generally defined as an excessive storage of energy reserves in the form of fat. Furthermore, obesity is a heterogeneous condition in terms of the topographical distribution of adipose tissue in each subject. The risks of obesity therefore depend on the distribution of fat as well as the total amount of fat. Perhaps an index of fat distribution, such as WHR, should be included in the definition of medically significant obesity in combination with the BMI.

The main criticism which has been given on the BMI as a measure of obesity is that it is less closely related to body fat than, for example, skinfold thickness⁴²). Skinfold thickness is a convenient method for measuring obesity, and skinfolds are well correlated with estimates of body fat based on density. However, we have found that there is considerable variation between the values obtained by particular methods of estimating body fat, such as skinfold thickness, density, and water or potassium content²¹). On the other hand, the practical advantages of BMI are obvious; both weight and height can be measured easily and accurately with simple equipment. According to various studies, BMI appears to be a reasonably good index of adiposity in adults^{2,12,18}). Previous

studies have suggested that the prevalence of hypertension, hyperlipidemia and hyperuricemia increases with the BMI^{15,25,37}). Therefore, it is now common to use the BMI as a reasonable index of obesity within a population because it is easy to measure and because it has shown reasonably good correlation with the more direct measurements of obesity. However, the BMI does not take into account frame size or variation in the body fat pattern, both of which may be related to the health risk profile.

In 1947 Vague⁴⁰) first reported the relationship between regional fat distribution and complications in obese subjects. The new techniques of CT and magnetic resonance imaging (MRI) now allow the direct non-invasive measurement of intra-abdominal fat depots³²). These techniques, however, are expensive and can only be used within hospitals and research centers, they cannot be used for routine community measurements. Kissebah et al.¹⁹) simplified the indicators of adipose tissue distribution by using WHR, and defined those with a high WHR as being obese in the upper body segment. Subsequently, the most popular measurement in recent years has been the WHR.

We propose the existence of three types of obesity based on BMI and WHR: Type-I, obese women who have a high BMI and a low WHR, Type-II, obese women who have a low BMI and a high WHR, and Type-III, obese women in whom both BMI and WHR are high. In the present study the association of these three types of obesity with metabolic features are examined in this group of Japanese women. Because of the possible effects of sex hormones on the results, similar analyses were performed within age categories, using aged 49 and below, aged between 50 and 59 yr, and aged 60 and over as cutoff points. The HDL-ch and HDL-ch/T-ch were significantly and inversely correlated with BMI and WHR, whereas TG, GL, SBP and DBP were positively correlated

with these variables. However, there was no significant association of WHR with any metabolic variable with the effects of the BMI partialled out in any group. The results of the present study show that the amount of body fat is in itself more important than the WHR. However, it is also evident that the WHR enhances the concomitant effects of obesity on metabolism. To investigate the pathogenic relationship of metabolic factors to the type of obesity, we calculated the BMI and WHR in sample women with metabolic parameter values higher or lower than the cut-off point for each metabolic variable. The mean values of the various metabolic variables across tertiles of a combination of the BMI and WHR were calculated for the three age groups separately. Where *p* values were significant, levels of these metabolic risk factors increased across tertiles, except for HDL-ch and HDL-ch/T-ch whose levels fell. Although the means of these metabolic parameters in each type of obesity were all within the normal range, significant differences were found in these parameters between obese women with high levels of BMI and WHR (Type-III) and the nonobese group were observed for these parameters. For women with Type-III obesity in each group, mean BMI values were 29.26, 28.95, and 28.49 and mean WHR values were 0.968, 1.020, and 1.013, respectively.

In conclusion, the most "dangerous" subgroup of obesity appeared to be Type-III obesity, because of the apparent metabolic complications associated with excessive abdominal fat. These findings suggest the importance of obesity in precipitating the metabolic abnormalities associated with the amount of body fat and an abdominal body fat distribution.

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