ORIGINAL ARTICLE

Overweight and Obesity-related Metabolic Disorders in Hospital Employees

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Background: Obesity is associated with metabolic disorders and cardiovascular diseases. This study investigated the relationship between overweight and obese status and the incidence of type 2 diabetes, hypertension, hyperlipidemia and hyperuricemia.

Methods: This prospective cohort study comprised 1749 hospital employees who received baseline health check-ups in 1993. Data from the 1027 participants (832 women, 195 men; mean age, 36 ± 7 years) who repeated check-ups in 2003 were used in the analysis. Relative risks (RRs) for development of metabolic disorders during follow-up associated with different body mass index (BMI) categories at baseline as defined by Asia-Pacific recommendations and the Department of Health in Taiwan were calculated after adjustment for covariates.

Results: The prevalence of overweight and obesity at baseline check-up were 17.6% and 14.5%, respectively. Obese subjects with baseline BMI ≥ 25 kg/m^2 had a significant multivariate-adjusted RR of 2.7 for hypertension, 14.8 for type 2 diabetes, 3.2 for hypertriglyceridemia, and 2.8 for hyperuricemia, compared to subjects with baseline BMI < 23.0 kg/m^2. RR for diabetes was higher in women than in men, but RR for hypertriglyceridemia was higher in men. The risks of hypertension and hyperuricemia significantly increased for subjects with baseline BMI ≥ 23 kg/m^2, while RRs for type 2 diabetes increased significantly for baseline BMI ≥ 24 kg/m^2 and hypertriglyceridemia increased for baseline BMI ≥ 25 kg/m^2. The risks attributable to obesity (baseline BMI ≥ 25 kg/m^2) were 23.0% for hypertension, 70.8% for diabetes, 27.9% for hypertriglyceridemia, and 24.1% for hyperuricemia.

Conclusion: This study revealed that a high prevalence of overweight and obesity was associated with significantly increased risk of development of type 2 diabetes, hypertension, hypertriglyceridemia and hyperuricemia in hospital employees, suggesting the need for programs to improve weight management. [*J Formos Med Assoc* 2006;105(1):56–63]

Key Words: body mass index, hypercholesterolemia, hypertension, hypertriglyceridemia, hyperuricemia, type 2 diabetes

Obesity, an epidemic in the industrialized world,[1–3] is also a growing problem in Taiwan, with nearly one quarter of the adult population currently overweight or obese.[4] Obesity is generally recognized as a major risk factor for the development of metabolic disorders, such as type 2 diabetes, hypertension, hyperlipidemia, and hyperuricemia. As body mass index (BMI) rises, the relative risk (RR) of type 2 diabetes also increases.[5–10] Willett et al[7] reported that for BMI > 26 kg/m^2 compared to BMI < 21 kg/m^2, the risk of diabetes was four times higher in males in the Health Professionals Follow-up Study,[6] and eight times higher in women in the Nurses' Health Study.[8] According to a World Health

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Organization report, the risks for type 2 diabetes and dyslipidemia are greatly increased in obese subjects, with RR > 3.0.[10]

Previous studies have demonstrated that the prevalence of hypertension increases with the degree of overweight.[11,12] Prospective investigation revealed an association between BMI > 20 kg/m^2 and increased incidence of hypertension in Japanese men.[13] The Finnish Heart Study found that higher BMI increased the risk of coronary mortality that was mediated through the link between body weight and blood pressure.[14] Obesity is also associated with hypertriglyceridemia. Further, abdominal obesity and high serum triglyceride levels are associated, a phenotypic characteristic known as the hypertriglyceridemic waist.[15] Positive cross-sectional associations between hyperuricemia and overweight have also been demonstrated for adult males in Taiwan and Japan.[16–18]

There has been a lack of prospective investigation exploring the relationship between obesity and the incidence of metabolic disorders related to cardiovascular diseases in Taiwan. The present study examined a cohort of hospital employees to determine the association between BMI and incidence of obesity-related metabolic disorders.

Methods

Subjects

Participants were employees of a teaching hospital in Taipei, Taiwan. In 1993, 1749 employees (> 20 years old) who had regular physical check-ups were recruited. Subjects who were pregnant at baseline, or who left work during the follow-up period, were excluded. A total of 1027 employees who worked full-time at the hospital throughout the 10.5-year study period (9.7–10.7) completed both the baseline check-up in 1993 and follow-up check-up in 2003. There were no significant differences at baseline between the study group and those with loss of follow-up in age, sex, BMI and prevalence of metabolic disorders.

Physical check-up

The baseline health examination in 1993 consisted of history taking, physical examination, anthropometric measurements (height, body weight), and measurements of blood pressure, fasting plasma glucose, total cholesterol, triglyceride and uric acid. BMI was calculated as weight in kilograms divided by the square of the height in meters. According to the BMI cutoffs suggested for Asians,[19] subjects were classified into normal (BMI < 23 kg/m^2), overweight (25 > BMI ≥ 23) or obese (BMI ≥ 25) categories. We also adopted the BMI cutoffs suggested by the Department of Health (DOH) in Taiwan in order to compare results obtained using these two definitions of excess weight. Accordingly, subjects were also classified into normal (BMI < 24), overweight (27 > BMI ≥ 24) or obese (BMI ≥ 27) categories. Venous blood was drawn after an overnight fast and analyzed at a central laboratory in a medical center. The health examination was repeated in 2003.

Definitions of hypertension, type 2 diabetes, hypercholesterolemia, hypertriglyceridemia and hyperuricemia

Hypertension was defined according to The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7), i.e. systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg, or physician-diagnosed hypertension.

Diabetes was defined according to the American Diabetes Association criteria. Medical charts were reviewed and a diagnosis of incident diabetes was confirmed if the subject met any one of the following criteria: (1) fasting plasma glucose level of at least 126 mg/dL and 2-hour postprandial plasma glucose level of at least 200 mg/dL; (2) elevated fasting plasma glucose level (≥ 126 mg/dL) on at least two different occasions; (3) treatment with hypoglycemic medication.

Hyperlipidemia was defined as serum total cholesterol ≥ 240 mg/dL and/or triglyceride ≥ 200 mg/dL. Hyperuricemia was defined as serum uric acid ≥ 7.5 mg/dL for men and ≥ 6.5 mg/dL for women.

Statistical analysis

SAS software (SAS Institute Inc, Cary, NC, USA) was used for all statistical analyses. The demographic characteristics of subjects were compared at the baseline health check-ups in 1993 and at the follow-up health check-ups in 2003 using the paired *t* test. In addition, for all incident analyses, prevalent cases of the specific outcome were excluded (e.g. cases of diabetes in 1993 were excluded from analyses of the incidence of diabetes). Differences in proportion data were assessed using the chi-square test. Multiple logistic regression was used to derive the RRs and 95% confidence intervals (CIs) to determine the 10-year risk of overweight and obesity for developing high cholesterol and/or triglyceride levels, hypertension, type 2 diabetes, and hyperuricemia. All logistic regression models were adjusted for age, sex, smoking status, alcohol intake and BMI change. The population attributable risk (PAR) was calculated using Levin's formula: $PAR = P_0(RR - 1)/P_0(RR - 1) + 1$; where P_0 is the proportion of the exposed population. All *p* values are 2-sided, with *p* less than 0.05 considered to be statistically significant. Means are presented with standard deviations.

Results

Table 1 summarizes the clinical characteristics at the start of this study in 1993 and at the end of the study in 2003 for the 1027 subjects with complete follow-up. At the time of the baseline health check-ups in 1993, mean age was 33.5 ± 7.2 years (range, 21–56 years). Mean BMI was 23.8 kg/m^2 for men and 21.6 kg/m^2 for women. The baseline prevalence of type 2 diabetes, hypertension, hypercholesterolemia, triglyceridemia and hyperuricemia was 1.0%, 12.9%, 3.2%, 3.5% and 5.9% in 1993, respectively, and all were more common in men than in women.

At the follow-up health check-ups in 2003, fasting plasma glucose, systolic blood pressure, serum cholesterol and triglyceride levels, but not diastolic blood pressure, were increased significantly, as determined by paired *t* test. A diagnosis of high

Table 1. Clinical characteristics of subjects (*n* = 1027) at baseline and 10.5 years later

	Baseline (1993)			10.5 years later (2003)		
	Total	Women	Men	Total	Women	Men
Age (yr)	33.5 ± 7.2	32.6 ± 7.1	37.3 ± 6.4	44.0 ± 7.1	43.1 ± 7.0	47.7 ± 6.3
Fasting plasma glucose (mg/dL)	90.0 ± 14.8	89.0 ± 14.2	94.2 ± 16.2	93.8 ± 19.2	92.9 ± 19.6	97.7 ± 16.8
BMI (kg/m^2)	22.0 ± 2.9	21.6 ± 2.8	23.8 ± 2.9	23.1 ± 3.4	22.7 ± 3.4	24.8 ± 2.9
Systolic blood pressure (mmHg)	114.1 ± 14.1	112.7 ± 14.2	119.8 ± 11.9	121.9 ± 18.5	120.1 ± 18.7	129.9 ± 14.9
Diastolic blood pressure (mmHg)	76.0 ± 9.4	75.1 ± 9.4	80.2 ± 8.3	71.9 ± 11.7	70.3 ± 11.3	78.9 ± 10.7
Total cholesterol (mg/dL)	181.9 ± 32.5	178.9 ± 31.3	190.0 ± 34.4	186.1 ± 32.5	183.9 ± 32.5	195.7 ± 30.8
Triglyceride (mg/dL)	90.2 ± 59.2	88.9 ± 44.9	125.0 ± 77.9	90.6 ± 84.7	80.5 ± 76.3	133.8 ± 103.6
Uric acid (mg/dL)	5.1 ± 1.5	4.7 ± 1.3	6.4 ± 1.4	5.6 ± 1.5	5.3 ± 1.3	7.2 ± 1.4
Prevalence						
Type 2 diabetes (%)	1.0	1.0	1.0	3.3	2.9	4.6
Hypertension (%)	12.9	10.7	22.1	20.4	17.2	33.9
Hypercholesterolemia (%)	3.2	2.2	7.7	6.4	5.1	12.3
Hypertriglyceridemia (%)	3.5	1.2	11.8	6.7	4.6	16.4
Hyperuricemia (%)	5.9	3.3	17.4	20.3	15.4	41.0
Overweight (%), 25 > BMI ≥ 23	17.6	14.4	31.3	19.8	17.2	30.8
Obesity (%), BMI ≥ 25	14.5	11.1	29.2	24.7	20.2	44.1
Overweight (%), 27 > BMI ≥ 24	16.6	12.4	34.4	21.1	17.4	36.9
Obesity (%), BMI ≥ 27	6.1	5.1	10.8	12.5	10.6	20.5

Data are presented as mean ± standard deviation or %. BMI = body mass index.

blood pressure was made in more than one fifth of subjects. Type 2 diabetes developed in approximately 2.3% of subjects. Among them, 90.9% (30/33) used hypoglycemia medications. Among subjects with hypertension, 54.1% (112/207) used antihypertensive medications in 2003. The prevalence of hypercholesterolemia and triglyceridemia had doubled at the follow-up health check-ups. Hyperuricemia was also significantly more prevalent at the follow-up in 2003 (5.9% vs. 20.3%).

Mean baseline BMI was 22.0 ± 2.9, with 67.9% of the subjects in the normal range, 17.6% overweight, and 14.5% obese according to Asia-Pacific recommendations, and 16.6% overweight and 6.1% obese according to DOH Taiwan criteria. Excessive weight was more common in men than in women. At the 10.5-year follow-up, the prevalence of overweight had increased by 2.2–4.5% and the prevalence of obesity had doubled. Further, the prevalence of BMI ≥ 30 rose from 1.5% to 4.7%.

The cumulative incidence of type 2 diabetes, hypertension, hypertriglyceridemia and hyperuricemia, but not hypercholesterolemia, increased progressively with higher baseline BMI (Table 2) as defined by either the Asia-Pacific or DOH criteria. Most metabolic disorders, such as type 2

Table 2. Cumulative incidence of obesity-related metabolic disorders at the 10.5-year follow-up by baseline body mass index (BMI) categories

	Baseline BMI categories (kg/m²) by Asian criteria				Baseline BMI categories (kg/m²) by DOH			
	< 23	23–24.9	≥ 25	*p*	< 24	24–26.9	≥ 27	*p*
Total								
n (%)	697 (67.9)	181 (17.6)	149 (14.5)		794 (77.3)	170 (16.6)	63 (6.1)	
Type 2 diabetes (%)	0.7	1.7	11.0	*	0.8	3.6	20.0	*
Hypertension (%)	10.2	25.4	31.4	*	12.0	25.2	40.5	*
Hypercholesterolemia (%)	4.1	8.4	7.1	†	4.8	7.1	6.9	
Hypertriglyceridemia (%)	3.3	7.1	13.1	*	3.7	7.8	20.4	*
Hyperuricemia (%)	12.4	24.6	33.3	*	13.6	30.6	31.3	*
Any one of the above (%)	25.9	45.2	60.0	*	27.5	50.8	60.6	*
Any two or more of the above (%)	5.1	14.7	22.9	*	8.5	25.9	45.8	*
Men								
n (%)	77 (39.5)	61 (31.3)	57 (29.2)		107 (54.9)	67 (34.4)	21 (10.8)	
Type 2 diabetes (%)	1.33	3.3	7.1	†	1.9	3.0	15.0	*
Hypertension (%)	21.4	30.9	40.0	†	23.7	35.6	42.9	†
Hypercholesterolemia (%)	8.1	14.3	8.0		9.6	10.2	11.8	
Hypertriglyceridemia (%)	6.6	10.0	23.9	†	7.0	14.3	37.5	†
Hyperuricemia (%)	23.3	40.8	43.6	†	28.6	44.9	28.6	
Any one of the above (%)	46.4	63.4	70.0	†	50.6	67.5	66.7	†
Any two or more of the above (%)	24.5	40.0	57.1	*	26.2	53.6	50.0	†
Women								
n (%)	620 (74.5)	120 (14.4)	92 (11.1)		687 (82.6)	103 (12.4)	42 (5.1)	
Type 2 diabetes (%)	0.7	0.8	13.5	*	0.6	3.9	22.5	*
Hypertension (%)	8.8	23.0	26.2	*	10.3	19.5	39.1	*
Hypercholesterolemia (%)	3.6	5.5	6.6		4.0	5.2	4.9	
Hypertriglyceridemia (%)	2.9	5.9	7.1	†	3.2	4.1	13.2	†
Hyperuricemia (%)	11.1	17.8	28.4	*	11.4	23.5	32.4	*
Any one of the above (%)	22.9	35.6	54.6	*	24.3	42.7	58.3	*
Any two or more of the above (%)	5.0	16.7	26.8	*	6.5	11.3	44.4	*

**p < 0.0001, †p < 0.05 (Cochran-Armitage Trend Test). DOH = Department of Health, Taiwan.*

diabetes, hypertension, hypertriglyceridemia and hyperuricemia (except hypercholesterolemia), occurred in parallel with increasing baseline BMI in both genders. The incidences of these metabolic disorders were significantly higher in men than in women. Subjects with BMI < 23 at baseline had the lowest rates of metabolic disorders at follow-up. In contrast, nearly 60% of subjects who were obese at baseline developed more than one metabolic disorder. The cumulative follow-up incidence of type 2 diabetes, hypertension, hypercholesterolemia, hypertriglyceridemia and hyperuricemia in subjects who were obese at baseline according to the Asia-Pacific criteria was 11.0%, 31.4%, 7.1%, 13.1% and 33.3%, respectively. Two or more metabolic disorders were found in 22.9% of subjects who were obese at baseline, but in only 5.1% of subjects with normal weight.

Multivariate analysis with adjustment for age, sex, smoking, alcohol intake and BMI change demonstrated that obese subjects were at significantly increased risk of developing type 2 diabetes, hypertension, hypertriglyceridemia and hyperuricemia, compared to subjects with normal BMI (Table 3). The odds ratio for type 2 diabetes was higher in women, but the odds ratio for hypertriglyceridemia was higher in men. The population attributable proportion (PAP) for obesity was

Table 3. Effect of baseline body mass index (BMI) categories on risk of subsequent metabolic disorders*

	Baseline BMI categories (kg/m²) by Asian criteria					Baseline BMI categories (kg/m²) by DOH				
	< 23	23–24.9		≥ 25		< 24	24–26.9		≥ 27	
	RR	RR (95% CI)	PAR (%)	RR (95% CI)	PAR (%)	RR	RR (95% CI)	PAR (%)	RR (95% CI)	PAR (%)
Total										
Type 2 diabetes	1	2.2 (0.5–9.4)	19.8	14.8 (5.0–43.6)	70.8	1	3.9 (1.2–13.0)	32.4	27.9 (9.7–80.3)	61.3
Hypertension	1	2.4 (1.5–3.9)	22.4	2.7 (1.6–4.5)	23.0	1	1.6 (1.0–2.6)	7.9	4.0 (1.9–8.4)	11.0
Hypercholesterolemia	1	1.7 (0.8–3.9)	12.6	1.4 (0.6–3.1)	6.6	1	1.1 (0.5–2.3)	1.5	1.2 (0.4–3.4)	1.1
Hypertriglyceridemia	1	1.8 (0.9–3.8)	14.2	3.2 (1.6–6.5)	27.9	1	1.5 (0.7–3.2)	7.2	5.5 (2.5–11.9)	19.8
Hyperuricemia	1	1.8 (1.2–2.8)	14.2	2.8 (1.7–4.5)	24.1	1	2.1 (1.4–3.3)	14.3	2.4 (1.2–4.8)	6.5
Any one of the above	1	1.7 (1.2–2.6)	–	3.0 (1.9–4.9)	–	1	1.9 (1.2–2.8)	–	3.8 (1.7–8.1)	–
Any two or more of the above	1	2.7 (1.5–5.0)	–	5.0 (2.6–9.9)	–	1	2.1 (1.1–4.1)	–	8.2 (3.1–21.4)	–
Men										
Type 2 diabetes	1	2.4 (0.2–28.1)	30.3	4.2 (0.4–42.9)	48.1	1	1.3 (0.2–10.1)	9.3	6.7 (0.9–49.2)	37.1
Hypertension	1	1.6 (0.7–3.9)	14.2	2.4 (1.1–5.8)	26.9	1	1.8 (0.8–3.9)	19.2	2.5 (0.7–8.5)	12.1
Hypercholesterolemia	1	2.1 (0.6–6.7)	25.5	1.0 (0.2–3.2)	0.0	1	1.0 (0.3–3.2)	0.0	0.7 (0.1–4.2)	2.9
Hypertriglyceridemia	1	1.7 (0.5–6.2)	16.9	5.1 (1.6–16.3)	52.3	1	2.5 (0.8–7.4)	32.8	8.9 (2.4–33.8)	42.3
Hyperuricemia	1	2.2 (1.0–4.9)	26.7	2.9 (1.2–6.8)	31.5	1	2.3 (1.1–4.9)	28.3	1.2 (0.3–4.4)	1.7
Any one of the above	1	1.9 (0.9–4.3)	–	2.6 (1.1–6.6)	–	1	2.0 (0.9–4.5)	–	1.9 (0.4–8.1)	–
Any two or more of the above	1	2.1 (0.7–5.9)	–	4.1 (1.4–12.2)	–	1	3.3 (1.3–8.5)	–	2.8 (0.5–15.5)	–
Women										
Type 2 diabetes	1	1.2 (0.2–10.5)	2.8	19.1 (5.7–63.7)	66.1	1	5.5 (1.3–23.0)	35.7	40.4 (11.5–143)	65.6
Hypertension	1	2.9 (1.7–5.2)	20.3	2.4 (1.2–4.6)	10.9	1	1.5 (0.8–2.8)	5.2	4.5 (1.7–11.6)	9.8
Hypercholesterolemia	1	1.4 (0.5–3.5)	5.1	1.5 (0.6–3.9)	5.2	1	1.0 (0.4–2.8)	0.0	1.0 (0.3–4.3)	0.0
Hypertriglyceridemia	1	1.9 (0.8–4.6)	11.5	2.0 (0.7–5.4)	9.3	1	1.1 (0.3–3.2)	1.2	3.6 (1.2–10.6)	10.8
Hyperuricemia	1	1.6 (0.9–2.7)	8.1	2.5 (1.4–4.4)	13.1	1	1.9 (1.1–3.4)	9.9	3.0 (1.4–6.7)	7.8
Any one of the above	1	1.6 (1.0–2.6)	–	3.1 (1.8–5.4)	–	1	1.7 (1.1–2.9)	–	4.4 (1.8–10.9)	–
Any two or more of the above	1	2.9 (1.4–6.3)	–	4.9 (2.0–11.6)	–	1	1.3 (0.5–3.4)	–	10.8 (3.4–34.7)	–

**Multiple logistic regression model: adjusted for age, gender, smoking status, alcohol intake and BMI change over the 10.5-year period. DOH = Department of Health, Taiwan; RR = relative risk; CI = confidence interval; PAR = population attributable risk.*

70.8% for type 2 diabetes, 23.0% for hypertension, 27.9% for hypertriglyceridemia, and 24.1% for hyperuricemia.

Subjects who were overweight at baseline as defined by the Asia-Pacific criteria were at significantly increased risk for hypertension (RR = 2.4) and hyperuricemia (RR = 1.8) during follow-up. Overweight subjects as defined by DOH criteria were also at increased risk for type 2 diabetes. No relationship was found between baseline BMI categories and incidence of hypercholesterolemia at follow-up in the multivariate analysis.

During the follow-up period, risk of development of any one or two of the metabolic disorders increased significantly with higher baseline BMI categories.

Discussion

This 10.5-year follow-up study has confirmed that the risk of metabolic disorders related to cardiovascular diseases increases progressively with higher baseline BMI regardless of whether Asia-Pacific or DOH criteria are used to define BMI categories. Further, the risks of hypertension and hyperuricemia were significantly increased for baseline BMI ≥ 23, while risk of type 2 diabetes increased significantly for baseline BMI ≥ 24, and risk of hypertriglyceridemia increased for baseline BMI ≥ 25.

As BMI increases, the RR of developing diabetes increases for both genders in many ethnic groups.[5–10] The risk was lowest when BMI was < 22 and 24 in the Nurses' Health Study[8] and the Health Professionals Follow-Up Study, respectively.[6] Tai et al found that the risk for diabetes in Chinese men with BMI > 25.3 was 2.9 times higher than for those with BMI < 21.3.[9] Our findings showing a strong relationship between obesity in adulthood and subsequent risk for type 2 diabetes over a 10.5-year period are consistent with previous research. The lowest risk for diabetes in this study was for subjects with BMI < 23, who had a 14-fold lower risk relative to their counterparts with BMI ≥ 25. Using DOH criteria, the risk of diabetes was significantly increased in overweight subjects with BMI 24–26.9.

As BMI increases, the RR of hypertension also progressively increases.[11,12] Previous study in a cohort of Japanese men revealed that, for BMI above 20 kg/m^2, increased BMI was associated with an increased risk for hypertension.[13] The Finnish Heart Study, a 15-year follow-up study performed in a cohort of 8373 Finnish women aged 30–59 years, found that for each increase in body weight of approximately 1 kg, the risk of coronary mortality increased by 1–1.5% that was mediated through the link between body weight and blood pressure.[14] This study demonstrated that, for BMI above 23 kg/m^2, an increase in baseline BMI was associated with increased risk of hypertension, a BMI threshold lower than that for diabetes. Development of hypertension was attributable to overweight or obesity in 45% of cases. Obesity is also associated with hypertriglyceridemia.[15,20,21] In this study, obesity was associated with an increased risk of developing hypertriglyceridemia in subjects with normal baseline triglyceride levels.

Positive cross-sectional associations have been demonstrated between hyperuricemia and overweight in adult males from Taiwan and Japan.[16–18] Hyperinsulinemia induced by insulin resistance reduces uric acid clearance, leading to hyperuricemia, with accumulation of visceral fat exacerbating the problem by increasing uric acid synthesis through the activation of triglyceride synthesis.[18] This study has shown that, for BMI > 23 kg/m^2, increased BMI is associated with increased hyperuricemia risk in subjects who had normal serum uric acid levels 10 years previously. Compared with subjects who had baseline BMI < 23, subjects who were overweight at baseline had a 1.8-fold increased risk of hyperuricemia, and obese subjects had a 2.8-fold increased risk at the 10.5-year follow-up. Further, 38.3% of hyperuricemia development was attributable to overweight or obese status at baseline.

The mechanisms leading to metabolic disorders associated with cardiovascular disease in obese persons are not completely known. It has

been hypothesized, however, that increased insulin resistance and hyperinsulinemia are contributors,[22,23] and both of these are reversible with weight loss.[24] Obesity affects metabolic disorders by the increased secretion of free fatty acids from fat and reduced production of adiponectin, which induce the insulin-resistant state, hyperinsulinemia, and diabetes and/or development of other metabolic disorders.[25] Hypertension may also develop due to sympathetic nervous system hyperactivity, and renal sodium reabsorption mediated by hyperinsulinemia. Hyperinsulinemia increases hepatic very low density lipoprotein, and triglyceride synthesis and secretion, which are associated with hypertriglyceridemia.

The optimal weight for avoidance of cardiovascular disease and prolongation of life remains controversial. In the Framingham Heart Study, each standard deviation increment in relative weight was associated with 15% and 22% increases in cardiovascular events in men and women, respectively, during 26 years of follow-up.[26] Kannel et al suggested that the optimal weight for avoidance of cardiovascular disease and prolonging life corresponds to a BMI of 22.6 for men and 21.1 for women. Analyzing data from the Nurses' Health Study[8] and the Health Professionals Follow-up Study,[6] Field et al demonstrated that adults in the healthy weight range (BMI 22–24.9) incurred an increased risk for non-communicable chronic diseases.[27] They suggested that adults should try to maintain a BMI between 18.5 and 21.9. A study from Japan found that the BMI associated with the lowest morbidity was 22.2 in men and 21.9 in women.[28] In this study, increased risks of developing metabolic disorders were found for subjects with baseline BMI > 23. The high prevalence of BMI greater than this level suggests the need for greater awareness and prevention of metabolic disorders related to overweight or obesity.

In conclusion, this study has demonstrated that excess BMI in adulthood increases the risk of developing type 2 diabetes, hypertension, hypertriglyceridemia and hyperuricemia. These results indicate the need for weight management programs in adults.

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