ORIGINAL RESEARCH

Examining the Links Between Lifestyle Factors and Metabolic Syndrome

Why do some overweight and obese people remain metabolically healthy?

In 2008, according to the World Health Organization (WHO), more than 1.4 billion adults were overweight and more than half a billion were obese,[1] and those numbers have likely increased since these data were reported. The WHO also reported that 44% of diabetes cases, 23% of ischemic heart disease cases, and 7% to 41% of certain cancers worldwide were attributable to overweight and obesity. Obesity is a serious health problem in many Western countries. According to the Organisation for Economic Co-operation and Development (OECD), in 2014, the United States was "the fattest country in the OECD," with an obesity prevalence of 36.5%.[2] Though the prevalence of obesity in Taiwan is lower, it has been rising steadily. Data gathered during successive 1993–1996 and 2005–2008 Nutrition and Health Surveys in Taiwan (NAHSIT) showed that the prevalence of obesity among Taiwanese men increased from 10.1% to 18.9%, while among Taiwanese women it increased from 12.7% to 17.1%.[3]

As Gogia and Agarwal have noted, while obesity isn't synonymous with metabolic syndrome, it is an integral feature.[4] The term *metabolic syndrome* refers to a cluster of cardiovascular risk factors, including central (abdominal) obesity, elevated blood glucose, high blood pressure, and dyslipidemia.[5,6] Metabolic syndrome has been associated with an increased risk of both cardiovascular mortality and overall mortality.[7,8] Many of the risk factors for obesity and for metabolic syndrome, such as increased intake of calorie-dense foods and decreased physical activity, are modifiable. The WHO has pointed to such factors as playing a role in the increasing burden of cardiovascular diseases.[9] We conducted this study in order to learn more.

BACKGROUND

Prevalence of metabolic syndrome. In the United States, according to an analysis of data from the 2003–2006 National Health and Nutrition Examination Survey (NHANES), the prevalence of metabolic syndrome in adults ranged from 34.3% to 38.5%.[5] In Europe, a study of more than 34,000 people from 10 European countries and the United States, conducted by the Metabolic Syndrome and Arteries Research Consortium, found that the prevalence of metabolic syndrome was 24.3%.[10] And an analysis of NAHSIT data from 1993–1996 and

By Shu-Hung Chang, PhD, MSN, Miao-Chuan Chen, MSN, Nai-Hui Chien, MSN, and Li-Yu Wu, MSN

ABSTRACT

Background: As it is in many other developed countries, obesity is a growing health concern in Taiwan, affecting nearly 20% of the adult population. Obesity can increase the risk of developing metabolic syndrome, diabetes, and cardiovascular disease. Recent data indicate that the prevalence of metabolic syndrome in Taiwan is 25.5%. Yet some overweight and obese individuals have normal metabolic profiles. It's not clear why some overweight or obese people remain metabolically healthy while others do not.

Purpose: The purpose of this study was to examine lifestyle risk factors for metabolic syndrome in people who are overweight or obese. We were particularly interested in distinguishing those lifestyle factors associated with metabolic health in this population.

Methods: Data collected from community-based physical examinations in northern Taiwan were used for this cross-sectional study. A survey was conducted from 2013 to 2014. We collected data on demographic variables, clinically pertinent measures (weight; height; waist circumference; blood pressure; and levels of fasting blood glucose, triglycerides, and high-density lipoprotein cholesterol), and lifestyle factors (smoking, drinking, exercise, and dietary habits). To analyze the data, we used percentage, mean, standard deviation, χ^2 test, independent *t* test, the Fisher exact test, phi correlation, and logistic regression.

Results: The overall prevalence of metabolic syndrome among all 734 participants was 36.4%. For the normal weight, overweight, and obese groups, the prevalence of metabolic syndrome was 12.4%, 36.4%, and 61.6%, respectively. The results of logistic regression showed, however, that obese individuals who exercised regularly and ate sufficient amounts of fruit were less likely to have metabolic syndrome, and that overweight individuals who were nonsmokers and ate sufficient amounts of vegetables were also less likely to have metabolic syndrome.

Conclusions: Lifestyle factors may significantly affect the development of metabolic syndrome in people who are overweight or obese. Our findings indicate that practicing healthy lifestyle behaviors may be the best way to prevent metabolic syndrome. Public health interventions promoting smoking cessation, regular exercise, and good dietary habits can be created and conducted at relatively low cost. At the community level, all nurses can prioritize such interventions for their overweight and obese patients.

Keywords: community health, lifestyle factors, metabolic syndrome, obesity, overweight, public health, risk reduction

2005–2008 found that the prevalence of metabolic syndrome was 25.5%.[3]

Risk factors. In the United States, Europe, and Taiwan, men were generally more likely to develop metabolic syndrome than women.[3, 5, 11] Obese individuals, older adults, heavy alcohol drinkers, smokers, and people who exercised less often or less rigorously were also more likely to develop metabolic syndrome.[5, 12-14] An analysis of data from the 2003–2006 NHANES by Bankoski and colleagues found that a higher percentage of sedentary time was associated with a significantly higher risk of metabolic syndrome, independent of physical activity.[15] And in another analysis of data from the 2003–2006 NHANES, Loprinzi and colleagues examined the dose–response relationship between physical activity and metabolic syndrome.[12] They found that people reporting the longest durations of both light and moderate-to-vigorous physical activity had the lowest rates of metabolic syndrome.

Diet has also been found to influence one's risk of metabolic syndrome. The WHO states that diets characterized by excessive intake of fat and sugar may increase this risk.[9] In Taiwan, an analysis of 1993–1996 and 2005–2008 NAHSIT data by Pan and colleagues showed that dietary habits have changed among adults ages 19 years and older.[16] Overall, the consumption of sweets doubled. Among women ages 19 to 30 years and men ages 31 to 64 years, caloric intake rose substantially as well. The authors cited these dietary changes, combined with a trend toward a more sedentary lifestyle, as factors in the rising prevalence of metabolic syndrome and associated diseases such as diabetes, hypertriglyceridemia, and gout. Dietary trends in the United States are less clear. Vadiveloo and colleagues studied data trends for participants in the Framingham Heart Study Offspring Cohort study between 1991 and 2008.[17] They found that the percentage of energy from total fat and protein increased, although the percentage of energy from carbohydrates decreased. But analyses of data from the 1971–1975 and 2005–2006 NHANES by Austin and colleagues yielded different results: the percentages of energy from total fat and protein decreased, while the percentage of energy from carbohydrates

Figure 1. Questionnaire on Metabolic Syndrome and Lifestyle Behaviors Among Community Residents

Coding No. _____

Dear Sir/Madam,
We appreciate your participation in this questionnaire. This questionnaire will take about 20 minutes to complete. We would like to learn about your daily health behaviors. We will keep your data confidential. Please feel comfortable answering this questionnaire. We wish you good health!
Sincerely,
Linkou Chang Gung Memorial Hospital and
Department of Nursing, Chang Gung University of Science and Technology

Demographic variables

1. Sex: ☐① male ☐② female
2. Age: _____ years old
3. Level of education: ☐① elementary school ☐② junior high school
   ☐③ senior high school ☐④ college[a] ☐⑤ university[b] ☐⑥ master's or doctorate
4. Marital status: ☐① married ☐② other
5. Employed:
   ☐① military ☐② government ☐③ business ☐④ industry ☐⑤ agriculture
   ☐⑥ self-employed ☐⑦ service industry ☐⑧ unemployed

Clinically pertinent data and measures

1. Body height: _____ cm
2. Body weight: _____ kg
3. Waist circumference: _____ cm
4. Blood pressure: (1) _____ mmHg (2) _____ mmHg
5. Blood glucose: _____ mg/dL
6. Triglycerides: _____ mg/dL
7. High-density lipoprotein cholesterol: _____ mg/dL

Lifestyle factors

1. Smoking habits:
   (1) Do you smoke cigarettes? ☐① I never smoke ☐② I smoked once
   ☐③ I do smoke [Please continue to question 1-(2).]
   (2) If you do smoke, how many cigarettes do you smoke each day? ____ cigarettes

2. Drinking habits:
   (1) Do you currently drink? ☐① I never or rarely drink ☐② I drink on special occasions
   ☐③ I sometimes drink ☐④ I drink almost every day [Please continue to question 2-(2).]
   (2) If you drink, how many drinks do you drink each day? ____ drinks

3. Regular exercise habits:
   (1) Have you exercised regularly in the last six calendar months for at least 20 minutes each time, with heart rate above 130 beats per minute and sweating at each session?
   ☐① No ☐② Yes [Please continue to question 3-(2).]
   (2) How often do you exercise regularly? (Please provide the frequency.) ____ days/week

4. Dietary habits:
   What are your dietary behaviors?
   (usually = behavior is performed all the time; often = behavior is performed most of the time; occasionally = behavior is performed sometimes; seldom = behavior is rarely performed; never = behavior is not performed at all)

Figure 1. Continued.

	Usually 5	Often 4	Occasionally 3	Seldom 2	Never 1
(1) Do you avoid excess amounts of salt and fat?					
(2) Do you try to consume an appropriate amount of protein every day (less than 60 grams)?					
(3) Do you try to consume enough vegetables every day (at least 1.5 bowls of cooked vegetables)?					
(4) Do you try to consume enough fruit every day (at least two types of fruit)?					
(5) Do you consume milk products every day (at least one to two glasses of milk)?					

[a] In Taiwan, "college" means a vice-bachelor's degree (the equivalent of an associate's degree in the United States).
[b] In Taiwan, "university" means a bachelor's degree.

increased.[18] That said, the researchers also found that overall energy intake increased "dramatically" and recommended interventions aimed at reducing this.

Some studies have found that people who adopted the Mediterranean diet were less likely either to develop metabolic syndrome or, if they already had it, to show improved clinical parameters.[19-21] The Mediterranean diet emphasizes consuming proportionally larger amounts of fruits, vegetables, whole grains, nuts, and fish, and smaller quantities of meat and snack foods. According to Yeh and colleagues' analysis of NAHSIT data from 1993–1996 and 2005–2008, eating larger amounts of vegetables, fruits, lean meat, and fish, as well as some traditional Taiwanese foods such as mushrooms, seaweed, and soybeans, lowered the risk of metabolic syndrome.[3] The typical Taiwanese diet is similar to the Mediterranean diet with regard to intake of vegetables, fruits, and fish. Differences include the Mediterranean diet's emphasis on whole grains, nuts, olive oil, and moderate wine consumption, while the Taiwanese diet incorporates the traditional Taiwanese foods. Although the two diets aren't exactly the same, both can reduce the risk of metabolic syndrome. There is some evidence that consuming avocado[22] and tree nuts[23] is also protective.

It's intriguing that normal metabolic profiles have been discovered among some overweight and obese individuals.[14, 24-26] Studies have found that between 10% and 40% of obese individuals are metabolically healthy, with some researchers crediting this to preserved insulin sensitivity.[14, 24-26] But researchers also found that metabolically healthy obese people were much more likely to develop metabolic syndrome within three to five years.[8, 25, 26] These studies generally did not address possible causes for the delayed onset of metabolic syndrome, and the presence of metabolic health in some obese people remains explained.

Purpose. The purpose of this study was to examine lifestyle risk factors for metabolic syndrome in people who are overweight or obese. We were particularly interested in distinguishing those factors associated with metabolic health in this population. We hypothesized that overweight or obese individuals who had healthier lifestyle behaviors would be less likely to develop metabolic syndrome.

METHODS

Design and sample. This cross-sectional study used data collected during community-based physical examinations conducted from May 2013 to June 2014 in 10 villages in northern Taiwan. The head of each village sought to recruit 75 participants via telephone calls, posters, and leaflets. All individuals older than 20 years were eligible for inclusion; a total of 742 people agreed to participate. The study was approved by the Chang Gung Medical Foundation Institutional Review Board in Taiwan. Participants signed consent forms before being examined and interviewed. Clinically pertinent data were assessed by six trained examiners, who then conducted in-person interviews using structured questionnaires. The interrater reliability was 0.92.

Measures. The structured questionnaires were designed to collect participants' demographic data, clinically pertinent data, and lifestyle behaviors (regular exercise, dietary habits, smoking, and drinking). (See Figure 1 for the complete questionnaire.)

Demographic variables included age, sex, highest education level, marital status, and employment status.

Table 1. Demographic Variables and Lifestyle Factors of All Participants (N = 734)

Variables	n (%)
Prevalence of metabolic syndrome, overall	267 (36.4)
Normal weight group (n = 250)	31 (12.4)
Overweight group (n = 247)	90 (36.4)
Obese group (n = 237)	146 (61.6)
BMI categories	
Normal weight	250 (34.1)
Overweight	247 (33.7)
Obese	237 (32.3)
Sex	
Female	474 (64.6)
Male	260 (35.4)
Employed	
Yes	305 (41.6)
No	429 (58.4)
Highest education level	
Less than high school	401 (54.6)
High school	168 (22.9)
College	165 (22.5)
Married	
Yes	567 (77.2)
No	167 (22.8)
Smoking	
Yes	63 (8.6)
No	671 (91.4)
Regular exercise	
Yes	315 (42.9)
No	419 (57.1)
Dietary habits	
Avoid excess salt and fat	
Often	389 (53)
Seldom	345 (47)
Eat enough vegetables	
Often	454 (61.9)
Seldom	280 (38.1)
Eat enough fruit	
Often	404 (55)
Seldom	330 (45)
Eat enough protein	
Often	389 (53)
Seldom	345 (47)
Consume milk products daily	
Often	203 (27.7)
Seldom	531 (72.3)
Met Taiwan's National Dietary Guidelines (5 items)	60 (8.2)
Met Taiwan's National Dietary Guidelines (4–5 items)	199 (27.1)
Years of age, mean (SD)	56.55 (13.7)

BMI = body mass index.

Clinically pertinent measures. The U.S. National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria were used to assess for metabolic syndrome. For a diagnosis of metabolic syndrome, the ATP III requires the presence of three or more of the following risk factors: elevated blood pressure (systolic, 130 mmHg or higher; diastolic, 85 mmHg or higher), elevated fasting blood glucose (100 mg/dL or higher), elevated triglycerides (150 mg/dL or higher), reduced high-density lipoprotein (HDL) cholesterol levels (less than 40 mg/dL in men and less than 50 mg/dL in women), and elevated waist circumference.[27] We modified the ATP III's definition of elevated waist circumference, using 90 cm or higher for men and 80 cm or higher for women, as recommended by Taiwan's Health Promotion Administration and by the WHO.[28-30]

Participants wore lightweight indoor clothing and no footwear during assessment of height and weight, which were measured to the nearest 0.1 cm and 0.1 kg, respectively. Body mass index (BMI) was calculated by dividing a person's weight by their height squared (kg/m^2). Taiwan's Health Promotion Administration classifies BMI into four categories: underweight, less than 18.5; normal weight, 18.5 to 24; overweight, 24 to 27; and obese, more than 27.[29]

To ensure accuracy, participants' blood pressure was taken twice, with a 5-minute rest between measurements. Overnight fasting blood samples were collected to determine blood glucose, triglycerides, and HDL cholesterol levels. Waist circumference was measured between the lowest rib and the iliac crest with the subject standing up straight, and was determined to the nearest 0.1 cm.

Lifestyle factors. Participants also recalled, described, and answered questions about their smoking, drinking, exercise, and dietary habits within the past six months.

Regarding smoking and drinking habits, participants were asked whether they smoked cigarettes, either in the past or presently. Current smokers were asked how many cigarettes they smoked daily. Participants were also asked whether they currently drank, and if so, how many drinks they consumed daily.

Regarding exercise, participants were asked, "Have you exercised regularly in the last six calendar months for at least 20 minutes each time, with heart rate above 130 beats per minute and sweating at each session?" and "How often do you exercise regularly?" Regular exercise was defined as exercising at least three days per week. These questions were based on Gionet and Godin's findings, which showed that asking such simple questions provided as accurate an assessment of physical activity as more elaborate methods.[31] In our study, after two weeks of data gathering, the test–retest reliability coefficient was 0.92 for self-reported regular exercise time.

Regarding dietary habits, participants were asked five questions based on the Taiwan Food and Drug Administration's National Dietary Guidelines.[32] These questions asked about participants' salt and fat intake, and daily consumption of protein, vegetables, fruit, and milk. Each question was answerable using a 5-point Likert-type scale (1, never; 2, seldom; 3, occasionally; 4, often; and 5, usually). For purposes of statistical analysis, answers were categorized into two groups, with responses of 4 or 5 categorized as "often" and responses of 1, 2, or 3 categorized as "seldom." After two weeks of data gathering, the test–retest reliability coefficient was 0.89 for self-reported dietary habits.

Participants who were overweight but did not have metabolic syndrome were more likely to be female, nonsmokers, and to report eating enough vegetables.

Data analysis. Data were analyzed using SPSS Statistics software, version 18 (SPSS Inc., Chicago). We analyzed the prevalence of metabolic syndrome, demographic characteristics, and lifestyle behaviors of all participants by percentage, means, and standard deviation. The Fisher exact test, χ^2 test, and independent *t* test analyses were used to compare demographic characteristics and lifestyle behaviors among overweight and obese individuals, with or without metabolic syndrome. Phi correlation analysis was conducted to estimate the correlation of risk factors for metabolic syndrome in the overweight and obese groups. Logistic regression analyses were conducted to estimate the effect of lifestyle behaviors on the development of metabolic syndrome in the overweight and obese groups. To identify which factors affect metabolic syndrome, all demographic and lifestyle variables were included in the logistic regression analysis. Except for age and education, all variables were entered as dichotomous variables (yes/no or seldom/often) in the logistic regression equations. Because only nine individuals were underweight, for the purpose of analysis they were included in the normal weight group.

RESULTS

Of the 742 people who agreed to participate in this study, 734 returned completed questionnaires, for a response rate of 98.9%. Thus the final sample size was 734.

Prevalence of metabolic syndrome. For all 734 participants, the prevalence of metabolic syndrome was 36.4%. We found that 250 (34%) participants were of normal weight, 247 (33.7%) were overweight, and 237 (32.3%) were obese. The prevalence of metabolic syndrome in the normal weight, overweight, and obese groups was 12.4%, 36.4%, and 61.6%, respectively.

Demographic and lifestyle variables. Of all participants, 64.6% were female and 35.4% were male. The mean age was 56.55 years (SD, 13.7). More than half of all participants (54.6%) had not finished high school. More than three-quarters (77.2%) were married and 91.4% were nonsmokers. Regarding exercise, 42.9% of participants reported exercising regularly. Regarding diet, 61.9% reported often eating a sufficient amount of vegetables, 55% reported often eating a sufficient amount of fruit, and 27.7% reported often consuming milk products. Only 8.2% of participants reported following Taiwan's National Dietary Guidelines; 27.1% reported following at least four of the five recommendations. Because just 12 participants reported regularly drinking alcohol, we left drinking behavior out of our analysis. For more detailed results, see Table 1.

Lifestyle-related risk factors for metabolic syndrome in overweight or obese participants. Among overweight participants with and without metabolic syndrome, the results of χ^2, the Fisher exact test, and independent *t* test analyses showed significant differences with regard to sex, smoking behavior, and whether they ate sufficient vegetables. Compared with overweight participants who had metabolic syndrome, those who were overweight but did not have metabolic syndrome were more likely to be female, nonsmokers, and to report eating enough vegetables.

Among obese participants with and without metabolic syndrome, the results of χ^2 and independent *t* test analyses showed that there were significant differences with regard to sex, whether they exercised regularly, and whether they ate sufficient fruit. Compared with obese participants who had metabolic syndrome, those who were obese but did not have metabolic syndrome were more likely to be female, to exercise regularly, and to report eating enough fruit. For more detailed results, see Table 2.

Table 2. Demographic Variables and Lifestyle Factors of Overweight and Obese Participants with and Without Metabolic Syndrome

	Overweight Group (n = 247)		Obese Group (n = 237)	
	Metabolic Syndrome (n = 90)	No Metabolic Syndrome (n = 157)	Metabolic Syndrome (n = 146)	No Metabolic Syndrome (n = 91)
Variables	n (%)	n (%)	n (%)	n (%)
Sex[a]				
Male	49 (54.4)	43 (27.4)	81 (55.5)	15 (16.5)
Female	41 (45.6)	114 (72.6)[b]	65 (44.5)	76 (83.5)[b]
Employed				
Yes	38 (42.2)	62 (39.5)	70 (47.9)	46 (50.5)
No	52 (57.8)	95 (60.5)	76 (52.1)	45 (49.5)
Highest education level				
Less than high school	57 (63.3)	90 (57.3)	72 (49.3)	47 (51.6)
High school	20 (22.2)	36 (22.9)	33 (22.6)	22 (24.2)
College	13 (14.4)	31 (19.7)	41 (28.1)	22 (24.2)
Married				
Yes	76 (84.4)	124 (79)	116 (79.5)	65 (71.4)
No	14 (15.6)	33 (21)	30 (20.5)	26 (28.6)
Smoking[c]				
Yes	12 (13.3)	4 (2.5)	16 (11)	8 (8.8)
No	78 (86.7)	153 (97.5)[d]	130 (89)	83 (91.2)
Regular exercise				
Yes	40 (44.4)	76 (48.4)	38 (26)	39 (42.9)[e]
No	50 (55.6)	81 (51.6)	108 (74)	52 (57.1)
Dietary habits				
Avoid excess salt and fat				
Often	43 (47.8)	72 (45.9)	66 (45.2)	40 (44)
Seldom	47 (52.2)	85 (54.1)	80 (54.8)	51 (56)
Eat enough vegetables				
Often	54 (60)	114 (72.6)[e]	82 (56.2)	48 (52.7)
Seldom	36 (40)	43 (27.4)	64 (43.8)	43 (47.3)
Eat enough fruit				
Often	52 (57.8)	85 (54.1)	64 (43.8)	62 (68.1)[e]
Seldom	38 (42.2)	72 (45.9)	82 (56.2)	29 (31.9)
Eat enough protein				
Often	51 (56.7)	84 (53.5)	86 (58.9)	54 (59.3)
Seldom	39 (43.3)	73 (46.5)	60 (41.1)	37 (40.7)
Consume milk products daily				
Often	34 (37.8)	44 (28)	24 (16.4)	19 (20.9)
Seldom	56 (62.2)	113 (72)	122 (83.6)	72 (79.1)
Years of age, mean (SD)[f]	60.46 (13.07)	57.34 (13.49)	55.69 (13.78)	52.52 (13.77)

[a]χ^2 test; [b]$P < 0.001$; [c]Fisher exact test; [d]$P < 0.01$; [e]$P < 0.05$; [f]t test.
Some values may not sum to 100% because of rounding.

In the overweight group, the results of phi correlation analysis showed that both sex and smoking behavior ($P = 0.000$) and sex and vegetable consumption ($P = 0.016$) were significantly correlated, so the logistic regression was adjusted for sex. In the obese group, there were no correlations among sex, exercise habits, and fruit consumption. Logistic regression analyses were then conducted to examine the overweight and obese participants by group. Participants who did not have metabolic syndrome were categorized into a reference group, and their lifestyle behaviors were compared with those of participants with metabolic syndrome in both the overweight and obese groups.

In the overweight group, nonsmokers were significantly less likely to have metabolic syndrome than smokers ($P = 0.019$). Participants who reported eating enough vegetables were also less likely to have metabolic syndrome than those who didn't ($P = 0.007$). Overweight women were more likely to be metabolically healthy than overweight men ($P = 0.002$). The details of the logistic regression analysis are shown in Table 3.

In the obese group, participants who exercised regularly were significantly less likely to have metabolic syndrome than those who didn't ($P = 0.012$). Participants who reported eating enough fruit were also less likely to have metabolic syndrome than those who didn't ($P = 0.019$). Obese women were more likely to be metabolically healthy than obese men ($P \leq 0.000$). The details of the logistic regression analysis are shown in Table 4.

DISCUSSION

Prevalence of metabolic syndrome in relation to lifestyle-related risk factors. In our community-based study, the overall prevalence of metabolic syndrome was 36.4%. This finding is comparable to the overall prevalence reported in the United States (34.3% to 38.5%)[5] and is higher than what has previously been reported in Taiwan (25.5%)[3] and Europe (24.3%).[10] Our results showed that the prevalence of metabolic syndrome was highest among obese participants; this result is similar to that indicated by Yeh and colleagues' analysis of NAHSIT data.[3]

In our study, less than half (42.9%) of participants reported exercising regularly. This finding is similar to that reported in a recent survey by the Taiwanese Ministry of Education's Sports Administration, which found that 33% of Taiwanese people exercised regularly and that 55.7% met the WHO's recommended level of physical activity or its "metabolic equivalent."[33,34] We also found that only about one-quarter of participants regularly consumed milk products or followed Taiwan's National Dietary Guidelines. These results are similar to those indicated by Pan and colleagues' analysis of NAHSIT data.[16] Clearly, both regular exercise and a healthier diet still need more effective promotion.

Lifestyle-related risk factors for metabolic syndrome in people who are overweight or obese. Our study findings add to the body of research indicating that risk of metabolic syndrome is modifiable through lifestyle changes. In our study, overweight participants who were nonsmokers were more likely to be metabolically healthy. Although overall, 36.4% of overweight participants had metabolic syndrome, the prevalence was lower among nonsmokers than smokers. This finding was consistent with those of earlier studies indicating that quitting smoking can help reduce the prevalence of metabolic syndrome.[35,36] In our study, overweight participants who ate enough vegetables also had a lower prevalence of metabolic syndrome, compared with those who did not. Prior research has yielded comparable findings. Studies conducted in the United States and Europe found that following a Mediterranean diet helped to reduce the prevalence of metabolic syndrome and cardiovascular disease.[19-21] And Yeh and colleagues, analyzing NAHSIT data, found that eating sufficient amounts of vegetables; fruit; lean meat; fish; and traditional Taiwanese foods such as mushrooms, seaweed, and soybeans could reduce the prevalence of metabolic syndrome.[3]

In our study, obese participants who exercised regularly were more likely to be metabolically healthy than those who did not. Earlier research has yielded similar results. Studies conducted among racially diverse populations and including normal weight, overweight, and obese individuals have found that people who regularly engaged in physical activity were more

There is evidence that metabolic health may be less stable in overweight and obese people than in people of normal weight.

likely to be metabolically healthy.[14, 25] Our study also found that obese participants who ate enough fruit were less likely to have metabolic syndrome. This result is similar to findings from studies conducted in the United States, Europe, and Taiwan.[3, 19-21]

But there is evidence that metabolic health may be less stable in overweight and obese people than in people of normal weight.[8, 25, 26] Chang and colleagues, studying nearly 2,600 Korean men, found that obese men who were metabolically normal were nearly twice as likely to develop metabolic syndrome as men of normal weight.[8] The cumulative incidences of metabolic syndrome among initially healthy obese participants at one year, two years, and three years' follow-up were 0.3%, 1.5%, and 2.7%, respectively. A study by Hwang and colleagues, conducted among more than 1,500 Taiwanese adults, yielded similar results.[26] Among obese participants who were metabolically normal at baseline, at 5.4 years' follow-up their cumulative incidences of hypertension, diabetes, and metabolic syndrome were 7.8%, 1.2%, and 5.6%, respectively.[26] In both studies, nearly 95% of participants who were metabolically normal and obese at baseline remained so; but neither study addressed the possible reasons for this. Our study revealed several modifiable lifestyle factors associated with metabolic health in people who are overweight and obese. Further investigation is warranted.

Implications. It is often difficult for people who are overweight or obese to reduce their weight so that it falls within a normal range and to maintain that healthier weight. It stands to reason that if such individuals were to focus not only on weight loss, but also on learning to dedicate themselves to health-promoting behaviors—such as quitting smoking, adhering to a regular exercise regimen, and consuming more vegetables and fruits—the prevalence of metabolic syndrome would decrease markedly.

Table 3. Demographic and Lifestyle Factors of Overweight Participants with and Without Metabolic Syndrome—Results of Logistic Regression Analysis[a]

Variables	Odds Ratio (95% CI)	*P* value
Characteristics		
Age	0.97 (0.94-1.01)	0.066
Sex (female/male[b])	2.86 (1.47-5.59)	0.002[c]
Employed (no/yes[b])	1.22 (0.59-2.54)	0.592
Education		0.846
Less than high school/college[b]	0.72 (0.23-2.27)	0.570
High school/college[b]	0.84 (0.30-2.37)	0.740
Married (no/yes[b])	1.10 (0.51-2.39)	0.807
Lifestyle factors		
Smoking (no/yes[b])	4.84 (1.30-18.03)	0.019[d]
Regular exercise (yes/no[b])	1.66 (0.91-3.04)	0.099
Dietary habits		
Avoid excess salt and fat (often/seldom[b])	0.83 (0.44-1.55)	0.559
Eat enough vegetables (often/seldom[b])	2.69 (1.31-5.53)	0.007[c]
Eat enough fruit (often/seldom[b])	0.72 (0.36-1.42)	0.338
Eat enough protein (often/seldom[b])	0.79 (0.42-1.52)	0.482
Consume milk products daily (often/seldom[b])	0.55 (0.29-1.04)	0.066

CI = confidence interval.
[a]Those without metabolic syndrome was the reference group.
[b]Mean comparison group. Adjusted for sex.
[c]$P < 0.01$.
[d]$P < 0.05$.

Table 4. Demographic and Lifestyle Factors of Obese Participants with and Without Metabolic Syndrome—Results of Logistic Regression Analysis[a]

Variables	Odds Ratio (95% CI)	*P* value
Characteristics		
Age	0.98 (0.94-1.01)	0.157
Sex (female/male[b])	12.73 (5.15-31.45)	≤ 0.000[c]
Employed (no/yes[b])	0.45 (0.20-1.03)	0.059
Education		0.952
Less than high school/college[b]	1.16 (0.36-3.75)	0.802
High school/college[b]	1.01 (0.37-2.77)	0.982
Married (no/yes[b])	1.45 (0.69-3.04)	0.324
Lifestyle factors		
Smoking (no/yes[b])	0.31 (0.10-1.02)	0.053
Regular exercise (yes/no[b])	2.37 (1.21-4.15)	0.012[d]
Dietary habits		
Avoid excess salt and fat (often/seldom[b])	0.89 (0.47-1.71)	0.732
Eat enough vegetables (often/seldom[b])	1.08 (0.54-2.15)	0.823
Eat enough fruit (often/seldom[b])	2.32 (1.15-4.76)	0.019[d]
Eat enough protein (often/seldom[b])	1.15 (0.59-2.26)	0.677
Consume milk products daily (often/seldom[b])	1.50 (0.66-3.39)	0.377

CI = confidence interval.
[a]Those without metabolic syndrome was the reference group.
[b]Mean comparison group.
[c]$P < 0.001$.
[d]$P < 0.05$.

Our findings specifically suggest that people who are overweight prioritize quitting smoking and eating more vegetables, and that people who are obese start exercising regularly and eating more fruit. For such individuals, these actions appear to play a significant role in lowering the risk of metabolic syndrome.

Limitations. This study had two limitations. First, because of the use of convenience sampling, the results may not be representative either of the general Taiwanese population or of diverse populations elsewhere. Second, because fewer than 2% of our participants reported drinking alcohol, data on drinking were not included; thus the results may not be generalizable to people who drink.

Despite these limitations, this study's findings indicate that practicing healthy lifestyle behaviors may be the best way to prevent metabolic syndrome. In the future, we plan to conduct randomized controlled clinical trials to study the effects of lifestyle interventions in people with metabolic syndrome.

FURTHER RECOMMENDATIONS

Effective prevention strategies could have major public health implications for the growing population of people worldwide who are overweight and obese. Although cost is always a concern for any public health program, in the long run, developing effective prevention strategies will help to reduce the socioeconomic burdens associated with metabolic syndrome. We believe that basic interventions promoting smoking cessation, regular exercise, and good dietary habits can be created and conducted at relatively low cost. Lachat and colleagues have noted that "better sharing of best practices and what works and what doesn't" is essential to good policy development, and nurses, especially public health nurses, belong at that table.[37] At the community level, all nurses can prioritize such

interventions for their overweight and obese patients, helping them to modify lifestyle behaviors for the better and lowering their risk of metabolic syndrome. ▼

For nine additional continuing nursing education activities on topics related to lifestyle changes, go to www.nursingcenter.com/ce.

Shu-Hung Chang is an associate professor and Miao-Chuan Chen, Nai-Hui Chien, and Li-Yu Wu are instructors in the Department of Nursing at Chang Gung University of Science and Technology, Taoyuan City, Taiwan. *This study was supported by funding from the Chang Gung Medical Foundation (CSRPF1A0011-13).* *Contact author: Shu-Hung Chang: shchang@mail.cgust.edu.tw.* *The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.*

REFERENCES

1. World Health Organization. *10 facts on obesity*. 2014. http://www.who.int/features/factfiles/obesity/en.
2. Organisation for Economic Co-operation and Development (OECD). *Obesity and the economics of prevention: fit not fat. Key facts—United States, update 2014*. Paris; 2014 May 27. https://www.oecd.org/unitedstates/Obesity-Update-2014-USA.pdf.
3. Yeh CJ, et al. Time trend of obesity, the metabolic syndrome and related dietary pattern in Taiwan: from NAHSIT 1993-1996 to NAHSIT 2005-2008. *Asia Pac J Clin Nutr* 2011;20(2):292-300.
4. Gogia A, Agarwal PK. Metabolic syndrome. *Indian J Med Sci* 2006;60(2):72-81.
5. Ford ES, et al. Prevalence and correlates of metabolic syndrome based on a harmonious definition among adults in the US. *J Diabetes* 2010;2(3):180-93.
6. International Diabetes Federation. *The IDF consensus worldwide definition of the metabolic syndrome*. Brussels; 2006. http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf.
7. Al Rashdan I, Al Nesef Y. Prevalence of overweight, obesity, and metabolic syndrome among adult Kuwaitis: results from community-based national survey. *Angiology* 2010;61(1):42-8.
8. Chang Y, et al. Impact of BMI on the incidence of metabolic abnormalities in metabolically healthy men. *Int J Obes (Lond)* 2012;36(9):1187-94.
9. World Health Organization. *Obesity and overweight [fact sheet]* 2016. http://www.who.int/mediacentre/factsheets/fs311/en.
10. Scuteri A, et al. Metabolic syndrome across Europe: different clusters of risk factors. *Eur J Prev Cardiol* 2015;22(4):486-91.
11. Dellios G. Epidemiology of metabolic syndrome in Europe [news release]. *Medical News Today* 2005 Sep 7. http://www.medicalnewstoday.com/releases/30241.php.
12. Loprinzi PD, et al. Dose response association between physical activity and biological, demographic, and perceptions of health variables. *Obes Facts* 2013;6(4):380-92.
13. Phillips CM, et al. Obesity and body fat classification in the metabolic syndrome: impact on cardiometabolic risk metabotype. *Obesity (Silver Spring)* 2013;21(1):E154-E161.
14. Wildman RP, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). *Arch Intern Med* 2008;168(15):1617-24.
15. Bankoski A, et al. Sedentary activity associated with metabolic syndrome independent of physical activity. *Diabetes Care* 2011;34(2):497-503.
16. Pan WH, et al. Diet and health trends in Taiwan: comparison of two nutrition and health surveys from 1993-1996 and 2005-2008. *Asia Pac J Clin Nutr* 2011;20(2):238-50.
17. Vadiveloo M, et al. Trends in dietary fat and high-fat food intakes from 1991 to 2008 in the Framingham Heart Study participants. *Br J Nutr* 2014;111(4):724-34.
18. Austin GL, et al. Trends in carbohydrate, fat, and protein intakes and association with energy intake in normal-weight, overweight, and obese individuals: 1971-2006. *Am J Clin Nutr* 2011;93(4):836-43.
19. Gomez-Huelgas R, et al. Effects of a long-term lifestyle intervention program with Mediterranean diet and exercise for the management of patients with metabolic syndrome in a primary care setting. *Eur J Intern Med* 2015;26(5):317-23.
20. Lankinen M, et al. Effects of whole grain, fish and bilberries on serum metabolic profile and lipid transfer protein activities: a randomized trial (Sysdimet). *PLoS One* 2014;9(2):e90352.
21. Steffen LM, et al. A modified Mediterranean diet score is associated with a lower risk of incident metabolic syndrome over 25 years among young adults: the CARDIA (Coronary Artery Risk Development in Young Adults) study. *Br J Nutr* 2014;112(10):1654-61.
22. Fulgoni VL, 3rd, et al. Avocado consumption is associated with better diet quality and nutrient intake, and lower metabolic syndrome risk in US adults: results from the National Health and Nutrition Examination Survey (NHANES) 2001-2008. *Nutr J* 2013;12:1.
23. O'Neil CE, et al. Tree nut consumption is associated with better adiposity measures and cardiovascular and metabolic syndrome health risk factors in U.S. Adults: NHANES 2005-2010. *Nutr J* 2015;14:64.
24. Bluher M. The distinction of metabolically 'healthy' from 'unhealthy' obese individuals. *Curr Opin Lipidol* 2010;21(1):38-43.
25. Bradshaw PT, et al. Metabolic syndrome in healthy obese, overweight, and normal weight individuals: the Atherosclerosis Risk in Communities study. *Obesity (Silver Spring)* 2013;21(1):203-9.
26. Hwang LC, et al. Prevalence of metabolically healthy obesity and its impacts on incidences of hypertension, diabetes and the metabolic syndrome in Taiwan. *Asia Pac J Clin Nutr* 2012;21(2):227-33.
27. Grundy SM, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement: executive summary. *Crit Pathw Cardiol* 2005;4(4):198-203.
28. Health Promotion Administration, Ministry of Health and Welfare (Taiwan). *[The criteria for metabolic syndrome among Taiwanese adults age 20 years over in 2007]* 2007. Chinese. http://www.hpa.gov.tw/BHPNet/Web/HealthTopic/TopicArticle.aspx?No=200712250123&parentid=200712250023.
29. Health Promotion Administration, Ministry of Health and Welfare (Taiwan). *[Body weight control, diet and exercise]* 2013. Chinese. http://www.hpa.gov.tw/BHPNet/Web/HealthTopic/TopicArticle.aspx?id=201308300012&parentid=201109290001.
30. World Health Organization, Western Pacific Region; the International Association for the Study of Obesity; and the International Obesity Task Force. *The Asia-Pacific perspective: redefining obesity and its treatment*. Manila, Philippines; 2000 Feb. http://www.wpro.who.int/nutrition/documents/docs/Redefiningobesity.pdf.
31. Gionet NJ, Godin G. Self-reported exercise behavior of employees: a validity study. *J Occup Med* 1989;31(12):969-73.
32. Health Promotion Administration, Ministry of Health and Welfare (Taiwan). *[Daily dietary guidelines]* 2012. Chinese. http://www.hpa.gov.tw/Bhpnet/Web/Books/Files/025/每日飲食指南手冊.pdf.
33. Shan S. Exercise rare among some women: poll. *Taipei Times* 2014 Dec 15. http://www.taipeitimes.com/News/taiwan/archives/2014/12/15/2003606791.
34. World Health Organization. *Global strategy on diet, physical activity, and health. Physical activity and adults*. 2016. http://www.who.int/dietphysicalactivity/factsheet_adults/en.
35. Cena H, et al. Prevalence rate of metabolic syndrome in a group of light and heavy smokers. *Diabetol Metab Syndr* 2013;5(1):28.
36. Kong HS, et al. Factors associated with metabolic syndrome and related medical costs by the scale of enterprise in Korea. *Ann Occup Environ Med* 2013;25(1):23.
37. Lachat C, et al. Diet and physical activity for the prevention of noncommunicable diseases in low- and middle-income countries: a systematic policy review. *PLoS Med* 2013;10(6):e1001465.