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Prevalence and Associated Characteristics of Metabolically Healthy Obese Phenotypes in a Community Dwelling Population

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Background: Recent research has focused on overweight and obese individuals with healthy metabolic profiles. Metabolically healthy and obese (MHO) individuals may have unique characteristics, compared to metabolically unhealthy obese (MUO) individuals. The purpose of this study was to evaluate the prevalence and clinical characteristics of both MHO and metabolically unhealthy normal-weight (MUNW) phenotypes in a community dwelling population.

Methods: Data from women (n=1,916) and men (n=867) aged 20 to 73 years who participated in the Health Examination of Nowon Health Care Center were analyzed. Subjects were categorized according to the presence, absence, or combination of metabolic syndrome and Asian-specific body mass index (BMI) criteria for overweight and obesity.

Results: The proportions of metabolic healthy individuals in the overweight and obese categories were 67% (overweight) and 39% (obese), respectively. The prevalence rate of the MUNW was 12% of normal weight individuals. Within the overweight and obese categories, MHO individuals tended to be younger compared with their MUO counterparts. High waist circumference (WC) and low high-density lipoprotein cholesterol (HDL-C) levels were two of the most common metabolic risk factors observed in the metabolically unhealthy group.

Conclusion: The prevalence of both MHO and MUNW phenotypes is relatively high in this community-dwelling population. There is an urgent need for the implementation of lifestyle intervention, consisting of regular exercise and healthy eating in the Nowon Health Care Center.

Key words: MHO, MUNW, Metabolic syndrome risk factor

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INTRODUCTION

Persons assessed as overweight or obese based on their body mass index (BMI) have a higher prevalence of metabolic complications, such as dyslipidemia, hypertension, and diabetes.[1,2] However, not all overweight or obese persons show metabolic risk. There are many persons with metabolically healthy obesity (MHO).[3,4] It has been reported that 18-44% of overweight or obese persons are metabolically healthy, with high insulin sensitivity and no diabetes, dyslipidemia, or hypertension.[3]

Metabolically unhealthy normal weight (MUNW) persons characteristically have a high risk of circulatory disease due to the exacerbation of arteriosclerosis from insulinemia, insulin resistance, hypertriglyceridemia, and hypertension.[5] However, no obesity is detected during evaluation based on body weight or BMI and therefore, individuals tend to neglect proper prevention programs or regular treatment, resulting in an increased prevalence of chronic diseases due to increased body fat mass, particularly abdominal vis-

ceral fat.[6] The proportion of the population with MUNW syndrome varies between 5 and 45%, depending on the criteria used, age, BMI, and race.[6]

MUNW, along with metabolic syndrome (MS), can lead to diminished muscle strength and physical activities, as well as circulatory disease.[7] Studies on MS have largely been conducted on obese people and very few studies have examined MUNW.[8,9] MS is a strong predictor of future circulatory disease and even the presence of one MS risk factor increases the risk of circulatory disease. In Korea, a relatively high number of persons have abdominal obesity according to their BMI and exposed to metabolic disorders.[10] Therefore, in order to issue proper prescriptions to people who visit health clinics, it is important to identify that these people belong to which groups. The objective of this study was to examine the proportion of community members visiting health clinics for health screening who fall under the categories of MHO and MUNW. This study also aims to investigate the association between BMI levels and MS risk factors.

METHODS

Subjects

The subjects in the present study consisted of 2,783 people (867 male and 1,916 female) who underwent MS testing at a healthcare center located in Nowon district of Seoul between January 1 and December 31 of 2012. The mean age, height, and weight of the male subjects were 44.3 ± 14.1 years, 171.4 ± 6.5 cm, and 72.1 ± 7.4 kg, respectively. The mean age, height, and weight of female subjects were 43.9 ± 12.4 years, 158.7 ± 5.7 cm, and 60.2 ± 6.2 kg, respectively.

Measurement items and methods

Body measurements

Subject height and weight were measured using a height/weight meter (BIKI200), while BMI was calculated using the formula BMI = weight (kg)/height (m^2). Body composition was measured in the fasting state, using a multi-frequency impedance device (T-scan plus; Jawon Medical, Korea). Waist circumference (WC) was determined using a measuring tape, measured in the standing position at the level of the umbilicus.

Biochemical indicators

Blood was obtained from the antecubital vein of all subjects after fasting for at least 10 hours. Collected blood was immediately separated using a 4°C centrifuge (3,500 rpm, 10 minutes). The separated plasma was analyzed for triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and blood glucose levels by an automatic biochemical analyzer (Hitachi, Japan) using commercially available reagents.

Diagnostic criteria for metabolic syndrome

Metabolic health was determined according to the diagnostic criteria for MS proposed by the National Cholesterol Education Program (NCEP), consistently with previous studies.[11] The criteria for metabolic syndrome were as follows: blood pressure (BP) ≥ 130/85 mmHg; glucose level ≥ 100 mg/dL; TG level ≥ 150 mg/dL; HDL-C levels < 50 mg/dL for women and < 40 mg/dL for men; and WC ≥ 85 cm for women and ≥ 90 cm for men.

Data processing

The present study used the Asia-Pacific BMI classification by the World Health Organization. Participants were classified as normal weight (BMI < 23), overweight (BMI 23-24.9), and obese (BMI ≥ 25) and divided into 6 groups for data processing. The groups were as follows:

Metabolically Unhealthy group

- MUO; metabolically unhealthy obese people: Obese (BMI ≥ 25) people with ≥ 2 MS risk factors
- MUOW; metabolically unhealthy overweight people: Overweight (BMI 23.0-24.9) people with ≥ 2 MS risk factors
- MUNW; metabolically unhealthy normal weight people: Normal weight (BMI < 23) people with ≥ 2 MS risk factors

Metabolically healthy group

- MHO; metabolically healthy obese people: Obese (BMI ≥ 25) people with < 2 MS risk factors
- MHOW; metabolically healthy overweight people: Overweight (BMI 23.0-24.9) people with < 2 MS risk factors
- MHNW; metabolically healthy normal weight people: Normal weight (BMI < 23) people with < 2 MS risk factors

Furthermore, as it is important to consider the difference between the sexes in WC and blood variables, the differences in the assessment variables between the metabolically unhealthy (MUOW, MUO, and MUNW) and healthy (MHOW, MHO, and MHNW) groups were analyzed using the two-way ANOVA, taking differences between the sexes into account. Tukey's HSD method was used for the post-hoc test. The statistical significance level was set at 5%.

RESULTS

The proportion of obese persons among the subjects was 23.2%, which was lower than the data reported by the Minister of Ministry of Health and Welfare (31.5%).[12] Fig. 1 shows the percentages of metabolically healthy and unhealthy people in different BMI categories. Metabolically healthy people, with < 2 MS risk factors, accounted for 39% and 67% of the obese and overweight group, respectively. Patients with no risk factors accounted for 10% and 34%, respectively. In the normal weight group, metabolically healthy people accounted for only 88% and the percentage of those with two or more MS risk factors was 12%.

Fig. 2 shows the proportion of MS risk factors in the different BMI groups. In the obese group, the most prevalent MS risk factor was high WC (71%), followed, in order, by low HDL-C (41%), elevated TG (40%), elevated glucose levels (23%), and hypertension (15%). In the overweight group, the most prevalent MS risk factor was low HDL-C (33%), followed, in order, by elevated TG levels (26%), abdominal obesity (26%), elevated glucose levels (18%), and hypertension (10%). In the normal weight group, low HDL-C was also the most prevalent risk factor (24%), followed by elevated TG (13%) and elevated glucose (11%) and hypertension (5%) and high WC (3%) were the least prevalent risk factors.

Table 1 shows the proportion of MS risk factors in the groups. In the metabolically unhealthy group, WC was the most prevalent risk factor in the obese group (85%), while low HDL-C was the most prevalent risk factor in the overweight and normal weight groups (69% and 74%, respectively). Furthermore, all metabolically unhealthy groups showed a high prevalence (> 60%) of TG and low

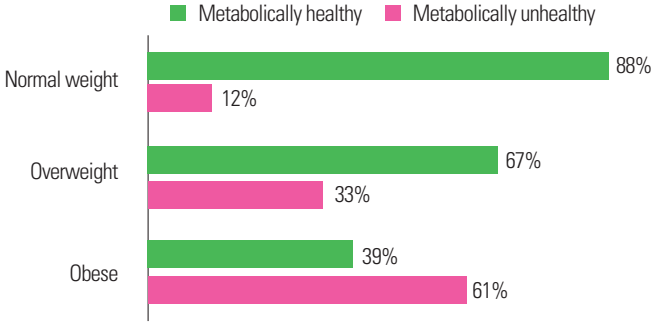

Figure 1. Prevalence of metabolically healthy and unhealthy people in the different body mass index (BMI) categories.

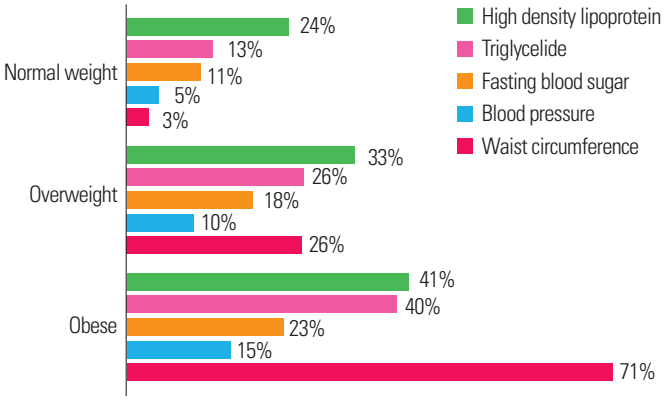

Figure 2. Percentage of metabolic syndrome risk factors in the different body mass index (BMI) categories.

Table 1. Percentage of metabolic syndrome risk factors in the groups

Parameters	Obese		Overweight		Normal weight	
	MUO	MHO	MUOW	MHOW	MUNW	MHNW
WC	85%	50%	49%	14%	19%	1%
BP	23%	2%	22%	4%	20%	3%
FBS	34%	6%	40%	7%	39%	7%
TG	60%	8%	61%	8%	69%	5%
HDL	63%	8%	69%	16%	74%	17%

MUO, metabolically unhealthy obese people; MHO, metabolically healthy obese people; MUOW, metabolically unhealthy overweight people; MHOW, metabolically healthy overweight people; MUNW, metabolically unhealthy normal weight people; MHNW, metabolically healthy normal weight people; WC, waist circumference; BP, blood pressure; FBS, fasting blood sugar; TG, triglyceride; HDL, high density lipoprotein.

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Table 2. Difference in the parameters among metabolically unhealthy groups

Parameters	Group	Male		Female			Two-way ANOVA	
		Mean	SD	Mean	SD		F-value	Post hoc. (Tukey's HSD)
Age	MUO	46.5	13.2	46.3	11.3	Sex	1.3	MUNW; M<F
	MUOW	49.9	12.3	51.8	10.7	Group	11.7*	F; MUO<MUNW
	MUNW	49.5	12.5	52.0	10.9	Interaction	9.5*	
Height	MUO	171.6	6.1	158.3	5.4	Sex	1,436.0*	M>F
	MUOW	170.5	6.1	158.0	4.8	Group	5.0*	F; MUO,MUOW>MUNW
	MUNW	171.6	6.1	158.0	5.7	Interaction	12.0*	
Weight	MUO	81.7	10.4	69.0	7.7	Sex	1,194.0*	M>F
	MUOW	69.8	5.6	59.9	3.9	Group	848.0*	MUO>MUOW>MUNW
	MUNW	63.6	5.3	53.7	4.6	Interaction	6.0*	
WC	MUO	94.5	7.1	91.0	6.2	Sex	152.7*	M>F
	MUOW	87.2	4.6	84.9	4.9	Group	558.6*	MUO>MUOW>MUNW
	MUNW	80.5	6.2	79.6	5.2	Interaction	0.7	
SBP	MUO	132.3	11.8	122.1	11.7	Sex	140.1*	M>F
	MUOW	129.2	11.3	122.5	12.7	Group	35.9*	MUO,MUOW>MUNW
	MUNW	126.4	9.2	121.6	15.2	Interaction	3.9*	
DBP	MUO	82.3	9.7	76.1	9.0	Sex	48.8*	M>F
	MUOW	80.4	9.1	75.9	8.7	Group	9.5*	MUO,MUOW>MUNW
	MUNW	80.0	8.9	76.1	10.6	Interaction	1.6	
FBS	MUO	103.6	34.1	95.8	16.6	Sex	38.3*	M>F
	MUOW	107.3	35.5	97.7	21.8	Group	2.7	
	MUNW	103.4	27.3	95.8	14.0	Interaction	1.3	
TC	MUO	205.2	40.6	201.3	37.5	Sex	12.9*	
	MUOW	198.7	32.4	200.8	51.4	Group	12.7*	F; MUO,MUOW<MUNW
	MUNW	196.9	39.8	206.8	42.4	Interaction	0.6	
TG	MUO	251.6	209.3	157.7	72.8	Sex	48.1*	M>F
	MUOW	219.8	132.0	168.5	97.3	Group	9.2*	F; MUOW<MUNW
	MUNW	190.0	79.3	175.7	66.7	Interaction	0.9	
HDL	MUO	42.7	8.9	46.1	9.0	Sex	96.1*	M<F
	MUOW	42.3	10.1	45.5	7.8	Group	10.8*	M; MUO<MUNW
	MUNW	43.9	10.6	47.2	10.1	Interaction	1.3	F; MUOW<MUNW
LDL	MUO	135.8	32.5	134.2	31.2	Sex	1.6	
	MUOW	132.6	27.8	132.6	34.7	Group	21.8*	M; MUO>MUNW
	MUNW	130.3	34.4	138.3	35.7	Interaction	0.3	F; MUO,MUOW<MUNW
SLM	MUO	55.0	6.3	40.2	4.6	Sex	2,873.0*	M>F
	MUOW	49.5	4.5	37.3	3.2	Group	194.0*	MUO>MUOW>MUNW
	MUNW	47.6	4.1	35.1	3.5	Interaction	20.0*	
PSLM	MUO	67.5	3.9	58.4	4.6	Sex	910.0*	M>F
	MUOW	70.8	2.3	62.2	3.6	Group	294.4*	MUO<MUOW<MUNW
	MUNW	74.8	3.7	65.4	4.7	Interaction	8.9*	
PBF	MUO	26.6	3.6	35.2	2.5	Sex	1,835.0*	M>F
	MUOW	23.5	2.3	31.6	1.6	Group	700.0*	MUO>MUOW>MUNW
	MUNW	19.4	3.8	28.2	2.9	Interaction	6.0*	
WHR	MUO	0.9	0.1	0.9	0.0	Sex	592.1*	M>F
	MUOW	0.9	0.0	0.8	0.0	Group	274.7*	MUO>MUOW>MUNW
	MUNW	0.9	0.1	0.8	0.0	Interaction	3.6	

Values are presented as mean and standard deviation (SD).
The differences in the assessment variables between the metabolically unhealthy (MUOW, MUO, and MUNW) groups were analyzed using the two-way ANOVA.
*P<0.05.
M, male; F, female; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; TG, triglyceride; SLM, soft lean mass; PSLM, %SLM; PBF, %body fat; WHR, waist hip ratio.
MUO, metabolically unhealthy obese people, n=394 (M 198, F 196); MUOW, metabolically unhealthy overweight people, n=188 (M 83, F 105); MUNW, metabolically unhealthy normal weight, n=180 (M 49, F 131).

Table 3. Differences in the parameters among metabolically healthy groups

Parameters	Group	Male		Female			Two-way ANOVA	
		Mean	SD	Mean	SD		F-value	Post hoc. (Tukey's HSD)
Age	MHO	41.6	13.7	45.6	12.8	Sex	2.3	
	MHOW	45.1	14.1	46.8	11.5	Group	12.1*	MHO <MHOW,MHNW
	MHNW	43.5	15.4	40.4	12.5	Interaction	1.0	
Height	MHO	172.1	6.5	157.5	6.0	Sex	796.9*	M>F
	MHOW	171.1	6.4	157.6	5.4	Group	1.0	
	MHNW	170.9	6.6	159.9	5.4	Interaction	0.4	
Weight	MHO	78.7	7.2	65.9	7.1	Sex	328.8*	M>F
	MHOW	70.1	5.6	59.2	4.3	Group	320.7*	MHO<MHOW<MHNW
	MHNW	62.0	6.0	52.0	5.0	Interaction	3.5*	
WC	MHO	90.7	4.9	86.5	6.2	Sex	21.6*	M>F
	MHOW	84.6	4.0	81.2	4.3	Group	261.2*	MHO<MHOW<MHNW
	MHNW	78.6	4.9	74.5	5.7	Interaction	2.8	
SBP	MHO	125.6	8.6	121.0	8.5	Sex	51.3*	M>F
	MHOW	125.8	11.1	116.9	9.9	Group	3.6*	MHO>MHNW
	MHNW	121.9	10.3	113.3	11.0	Interaction	2.9	
DBP	MHO	75.8	6.6	73.9	6.6	Sex	40.8*	M>F
	MHOW	76.5	7.8	72.6	8.1	Group	1.2	
	MHNW	74.8	8.1	70.9	8.1	Interaction	1.0	
FBS	MHO	90.8	7.6	88.8	7.8	Sex	15.8*	M>F
	MHOW	93.0	11.6	88.4	7.3	Group	0.9	
	MHNW	91.2	13.8	87.4	8.7	Interaction	0.1	
TC	MHO	194.4	34.8	204.7	37.3	Sex	0.5	
	MHOW	190.9	35.6	198.6	34.4	Group	0.5	
	MHNW	185.7	36.2	190.2	35.3	Interaction	1.5	
TG	MHO	112.5	59.7	95.8	41.0	Sex	26.6*	MHO; M>F
	MHOW	109.1	51.4	96.1	41.7	Group	1.4	
	MHNW	104.4	54.3	84.5	33.7	Interaction	5.1*	
HDL	MHO	49.9	8.7	58.2	9.1	Sex	20.5*	M<F
	MHOW	51.7	9.5	57.5	10.0	Group	1.1	
	MHNW	54.3	12.3	60.0	12.0	Interaction	0.0	
LDL	MHO	128.2	31.3	132.4	32.5	Sex	0.6	
	MHOW	124.3	31.2	126.1	30.0	Group	0.3	
	MHNW	116.9	30.4	117.7	29.4	Interaction	1.2	
SLM	MHO	54.3	5.4	39.4	4.2	Sex	1,153.0*	M>F
	MHOW	50.8	5.1	37.2	3.4	Group	114.0*	MHO>MHOW,MHNW
	MHNW	47.1	5.6	35.5	3.5	Interaction	7.0*	
PSLM	MHO	69.1	3.4	59.9	3.4	Sex	756.7*	M>F
	MHOW	72.4	2.8	62.9	3.5	Group	171.8*	MHO<MHOW<MHNW
	MHNW	75.9	5.9	68.6	5.1	Interaction	0.4	
PBF	MHO	25.2	3.4	34.1	2.7	Sex	1,351.0*	M<F
	MHOW	21.8	2.8	31.1	2.0	Group	343.0*	MHO>MHOW>MHNW
	MHNW	17.4	3.6	25.3	3.7	Interaction	1.0	
WHR	MHO	0.91	0.1	0.84	0.0	Sex	623.7*	M>F
	MHOW	0.89	0.1	0.82	0.0	Group	87.6*	MHO>MHOW>MHNW
	MHNW	0.85	0.1	0.77	0.0	Interaction	1.0	

Values are presented as mean and standard deviation (SD).

The differences in the assessment variables between the metabolically healthy (MHOW, MHO, and MHNW) groups were analyzed using the two-way ANOVA.

*$P<0.05$.

M, male; F, female; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; TG, triglyceride; SLM, soft lean mass; PSLM, %SLM; PBF, %body fat; WHR, waist hip ratio.

MHO, metabolically healthy people, n=250 (M 126, F 124); MHOW, metabolically healthy overweight people, n=376 (M 142, F 234); MHNW, metabolically healthy normal weight, n=1,391 (M 265, F 1126).

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HDL-C levels. In the metabolically unhealthy group, the overweight and normal weight groups were older than the obese group. The metabolically unhealthy groups tended to be older than the metabolically healthy groups.

Table 2 shows the differences in parameters among the metabolically unhealthy groups. Among the metabolically unhealthy groups, there were inter-group differences in BP and blood parameters and specifically, BP was higher in the obese and overweight groups than in the normal weight group. Furthermore, among metabolically unhealthy female subjects, higher TC, TG, and low-density lipoprotein cholesterol (LDL-C) levels were observed in the normal weight group than those in the obese or overweight group.

Table 3 shows the differences in parameter among the metabolically healthy groups, a significant difference in systolic blood pressure (SBP) was found between the obese and normal weight groups, while no differences in blood variables were observed between the groups.

DISCUSSION

In the present study, MHO accounted for 14% of all subjects and 39% of obese persons. According to the study design and specifically, to the defining criteria, the reported prevalence of MHO ranges from 2.2 to 11.9% in the general population and from 6 to 40% among obese persons.[13] Goday et al.[14] and Schröder et al.[15] reported that the prevalence of MHO among all subjects was 8.6% and 6.5%, respectively. Goday et al.[14] reported that metabolically healthy people can be classified as overweight (87.1% of cases) and obese (55.1% of cases). The proportion of overweight and obese persons was higher than that observed in the present study (67% and 39%, respectively). In a review article by Boonchaya-anant et al.[16], the reported proportion of MHO among obese persons was 2-30%. One of the reasons for these differences is due to the use of a different number of risk factors to define healthy obesity. Goday et al.[14] defined MHO as the presence of 0-2 risk factors and MUO as the presence of ≥ 3 risk factors. When these definitions were applied more stringently, MHO was defined as the absence of any risk factor. The present study also defined MHO as the presence of < 2 MS risk factors, and applying this criterion, 10% of obese people were metabolically healthy.

Recent studies reported that individuals with MHO display favorable metabolic profiles, characterized by high levels of insulin sensitivity, no hypertension, and favorable lipid, inflammation, hormonal, liver enzyme, and immune profiles.[3] Currently, the MHO group has a lower risk for MS, although it has high potential risks for circulatory diseases, exacerbation risk for diabetes, long-term mortality rate, and markers.[17] Therefore, this group requires an active lifestyle intervention, including nutrition and exercise.[18]

Following a review of studies examining the amount of physical activities, Roberson et al.[17] reported that the MHO group was more physically active than the MUO group and increased physical activities were able to offset the exacerbation of circulatory diseases in the MHO group. Obese persons who follow dietary recommendations and engage in high intensity physical activities are likely to change their status to MHO.[13]

Persons with MUNW have high fat mass and low muscle mass. Although the MUNW group had a higher percentage of body fat than the MHNW group, the difference in muscle mass was not significant; however, the ratio of muscle mass to body weight (% soft lean mass; PSML) tended to be lower in the MNUW group than in MHNW group.

Reduced muscle mass and increased fat, exacerbate insulin resistance causing MS. Even after controlling for age and sex, the MUNW group was associated with severity and prevalence of coronary artery diseases independently of diabetes.[19]

In the normal weight group, 41% of persons had > 1 MS risk factor, while 12% had ≥ 2 risk factors. Conus et al.[6] reported that the percentage of MUNW was 5-45%. Meigs et al.[11] showed that both heart disease and diabetes were more prevalent in MUNW (21.3% and 11.3%, respectively) than in MHO (8.1% and 3%, respectively), confirming that assessing health status by body weight alone was not desirable. Hosseinpanah et al.[20] followed up 6,215 community residents aged 30 years or older with no circulatory diseases, and found that persons with MUNW had a higher risk for circulatory diseases than those with MHO.

Choi et al.[21] studied elderly subjects and found that the overall mortality rate and the mortality rate associated with circulatory diseases were the highest in the MUNW group and lowest in the MHOW group. Kim[8] noted that as the rate of energy intake from carbohydrates and fat was not associated with the risk of MUNW, regular exercise could reduce the risk of being MUNW. Meanwhile

Conus et al.[22] and Lee et al.[23] also mentioned that the most significant cause of being MUNW was lack of physical activity. Dalzill et al.[24] reported that a 9 months intervention with dietary education and exercise training program resulted in improvements in MS risk factors for MUNW, insulin sensitivity, and physical fitness variables. The MUNW group is less active than healthy groups and reduced physical activity increases the risk of being MUNW.[9,23,25] Therefore, even if the body weight is within the normal range, people with MS risk factors should be screened carefully for coronary artery disease and lifestyle improvement, specifically exercise therapy, should be considered.

In conclusion, healthy lifestyle education and program interventions are necessary for individuals with MHOW and MHO, as there is a high probability that they may suffer from poor health in the future. Moreover, regardless of body weight, aerobic exercise should be recommended for metabolically unhealthy groups, as these individuals have the greatest risk factors for metabolic disorder, specifically, high WC and low HDL-C levels. Future studies should examine the optimal exercise regimen for healthy obese and unhealthy normal weight persons.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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