Short Communication

Metabolically obese but normal weight (MONW) and metabolically healthy but obese (MHO) phenotypes in Koreans: characteristics and health behaviors

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The purpose of this study was to estimate the prevalence of 'metabolically obese, but normal-weight' (MONW) and 'metabolically healthy, but obese' (MHO) phenotypes in Korean adults and identify the characteristics and health behaviors related to both phenotypes. Of the 5267 participants (2227 men, 3040 women) from the 3rd Korean National Health and Nutrition Examination Survey, the MONW phenotype (8.7% of total subjects, 12.7% of normal-weight subjects) was defined as individuals of normal weight (BMI < 25) with the metabolic syndrome (MS), and the MHO phenotype (15.2% of total subjects, 47.9% of obese subject) was defined as obese individuals (BMI ≥ 25) without the MS. The odds ratio for MONW phenotype was significantly higher for those at older age, those with lower education, those who had moderate alcohol consumption, and time spent participating in moderate-intensity exercise. The odds ratio for MHO phenotype was significantly lower for those at older age, men, those with lower education, and former/current smokers. In conclusion, regardless of weight status, health behaviors should be modified to prevent MS.

Key Words: metabolically obese but normal-weight, metabolically healthy but obese phenotype, prevalence, health behaviors, Korean

INTRODUCTION

The standard relationship between weight status and metabolic health is not applicable for some subtypes of individuals. The subtypes are known as 'metabolically obese, but normal-weight' (MONW) and 'metabolically healthy, but obese' (MHO) phenotypes.[1] The former phenotype are those who are normal weight with an abnormal metabolic status. On the other hand, the latter phenotype is those with a normal metabolic profile who is obese. The importance of this phenotype classification is based on findings that abnormal metabolic status, rather than a high BMI, is associated with a higher risk for developing type 2 diabetes, having a major cardiovascular event or dying.[2] Therefore, identifying potential risk factors associated with the MONW will be important to decide if health behaviors should be modified. Likewise, the factors associated with the MHO will indicate effective ways to prevent obesity-related metabolic abnormalities. The prevalence of the MONW and MHO phenotypes and several related characteristics of those phenotypes have been reported from Western populations,[2,3] while information among Asian populations is scarce.

The current study estimates the prevalence of the MONW phenotype and the MHO phenotype in Korean adults, and to identify socio-demographic and health behaviors related to those subtypes.

MATERIALS AND METHODS

Data were obtained from 5267 subjects (2227 men, 3040 women) who participated in the third Korean National Health and Nutrition Examination Survey, a community-based cross-sectional survey conducted in 2005 by the Korean Ministry of Health and Welfare.[4] The MONW phenotype was defined as the status of having normal weight (BMI < 25 kg/m^2) but fulfilling the metabolic syndrome (MS) criteria (≥ 3 abnormal metabolic components). In contrast, the MHO phenotype was defined as the status of being obese (BMI ≥ 25 kg/m^2),[4,5] but not having the MS. The following criteria were used to define abnormal metabolic components: waist circumference (WC) of ≥ 90 cm for men and ≥ 85 cm for women[6]; blood pressure (BP) of ≥ 130/85 mmHg; glucose of ≥ 100 mg/dL; high density lipoprotein cholesterol (HDL) of < 40 mg/dL for men or < 50 mg/dL for women; and triglyceride (TG) of ≥ 150 mg/dL.[7] Of individuals with normal weight, 6.3% had high WC. Individuals who had normal weight but had high WC were classified as normal weight category. Self-reported questionnaires were used to assess smoking status, alcohol intake, the spending time per week in high-intensity exercise, moderate-intensity exercise, and walking. Daily energy intake and macronutrients intake were evaluated using a structured food frequency questionnaire. The study protocol conforms to the ethical

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guidelines of the 1975 Declaration of Helsinki as reflected in *a priori* approval by the Inje University Busan Paik Hospital institutional review board in Korea. Multivariate logistic regression analyses estimated the odds ratios of the MONW and MHO phenotypes in terms of age, gender, educational attainment, and health behaviors.

RESULTS

Overall, of the 5267 subjects, the prevalence for obesity and MS was 32% and 25%, respectively (26% for high WC, 32% for high BP, 22% for high glucose, 56% for low HDL, and 28% for high TG). The prevalence of the MONW phenotype (i.e. individuals with MS and normal weight, n=456) was 8.7% (10.1% among men, 7.6% among women), and the prevalence of the MHO phenotype (i.e. individuals without MS but with obesity, n=799) was 15.2% (15.5% among men, 14.9% among women). When stratified by BMI category, 12.7% of normal-
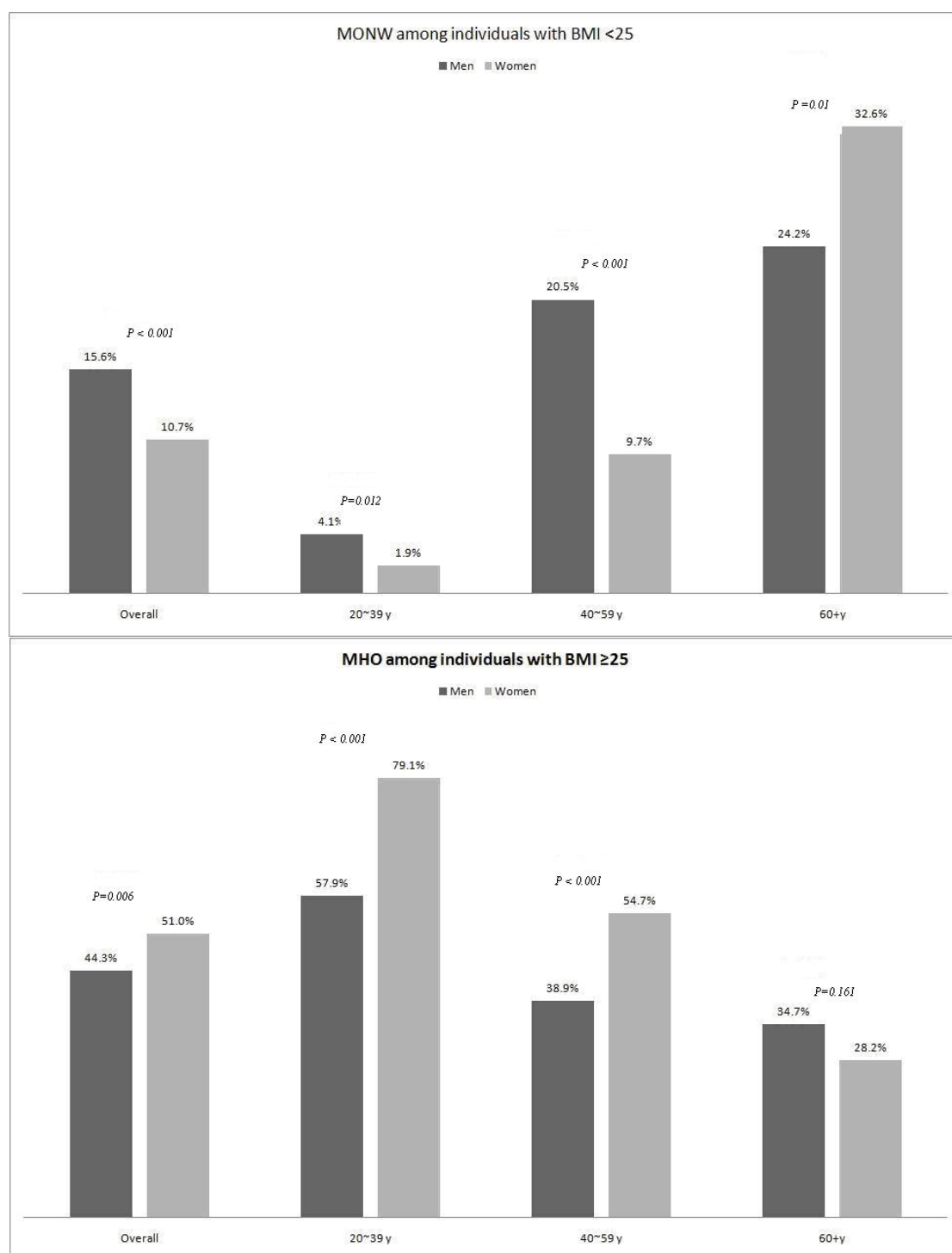

Figure 1. The prevalence of the MONW phenotype among normal-weight subjects and the MHO phenotype among obese subjects from the third KNHANES. Note: MONW: metabolically obese, but normal weight (i.e., those having MS and BMI < 25 kg/m^2); MHO: metabolically healthy, but obese (i.e., those not having MS with BMI $\geq$ 25 kg/m^2); KNHANES: Korean National Health and Nutrition Examination Survey

weight subjects (15.6% of men, 10.7% of women, $p <$ 0.001) met the MS definition, and 47.9% of obese subjects (44.3% of men, 51.0% of women, p =0.006) possessed a healthy metabolic status (Figure 1). In the multivariate logistic regression model, older individuals were more likely to be MONW, while those individuals who attained higher education, were moderate drinkers ($\leq$ 2 drink/day), and spent longer time doing moderate-intensity exercise were less likely to be MONW. After adjusting for confounders, older individuals, men, those had lower education, and current smokers were more likely to be metabolically obese among obese subjects (Table 1).

DISCUSSION

According to the limited number of available studies, the reported prevalence of the MONW and MHO phenotypes has been widely ranged, dependent on the characteristics of the subjects and the diagnostic criteria.[2,3] The prevalence of the MONW phenotype in the current study population is almost twice that found in the U.S. population, although the definition of the MONW phenotype in both studies are the same.[2] Likewise, when compared to the prevalence of the MHO phenotype reported by Meigs et al.,[2] the prevalence of the MHO phenotype for those with

BMIs between 25 and 29.9 kg/m^2 was 49% in Koreans compared to 73% in the U.S. population. Therefore, current studies confirm ethnic differences in the prevalence of the MONW and MHO phenotypes and suggest relatively higher metabolic abnormalities in the same BMI category in Asian populations. Older age and lower education among study population and obese men are associated with an undesirable metabolic status. In contrast, moderate drinking ($\leq$ 2 drinks/day) and moderate-intensity exercise among individuals with normal weight, and never-smoking among obese individuals were associated with a desirable metabolic profile. The advantage of moderate-intensity exercise in improving insulin sensitivity was documented in a previous study. However, the underlying mechanism with regard to differences in the benefit by exercise intensity is not completely explained.[8] The beneficial effect of moderate alcohol consumption on the presence of MS may be related to alcohol's influence on lipid profile and insulin sensitivity. However, the relationship between alcohol consumption and the MS has been controversial because both protective and detrimental effects have been reported.[9] Smoking[10] also seems to be unfavorable in terms of insulin resistance.

In conclusion, generally recommended health behaviors such as moderate-intensity exercise, moderate alco-

Table 1. Odds ratios (ORs) for being metabolically obese relative to being metabolically normal among normal-weight subjects and odds ratios for being metabolically obese relative to being metabolically healthy among obese subjects from the third KNHANES.

	MONW vs. MHNW		MOO vs. MHO	
	Crude OR (95% CI)	Adjusted OR (95% CI)*	Crude OR (95% CI)	Adjusted OR (95% CI)*
Age				
20-39 y	1.0	1.0	1.0	1.0
40-59 y	6.1 (4.3-8.7)	4.7 (3.2-6.9)	2.2 (1.8-2.9)	1.9 (1.4-2.6)
$\geq$ 60 y	14.7(10.4-21.0)	9.0 (5.8-13.8)	4.6 (3.5-6.1)	3.3 (2.2-4.9)
Gender				
Men	1.0	1.0	1.0	1.0
Women	0.6 (0.5-0.8)	0.8 (0.5-1.1)	0.8 (0.6-0.9)	0.7 (0.5-0.9)
Education				
$\leq$ Middle school	1.0	1.0	1.0	1.0
High school	0.3 (0.3-0.4)	0.7 (0.6-0.9)	0.5 (0.4-0.6)	0.6 (0.4-0.8)
> High school	0.2 (0.1-0.2)	0.5 (0.4-0.7)	0.4 (0.3-0.5)	0.6 (0.4-0.9)
Smoking				
Never	1.0	1.0	1.0	1.0
Current	1.6 (1.3-2.0)	1.2 (0.8-1.7)	1.4 (1.1-1.7)	1.5 (1.1-2.2)
Former	1.8 (1.4-2.3)	1.0 (0.7-1.5)	1.5 (1.2-2.0)	1.4 (0.9-1.9)
Alcohol intake				
Non-drinkers	1.0	1.0	1.0	1.0
1-2 drink /day	0.4 (0.4-0.6)	0.7 (0.6-0.9)	0.6 (0.5-0.8)	0.7 (0.5-1.1)
3-4 drink/day	0.9 (0.6-1.4)	1.2 (0.8-1.9)	0.8 (0.6-1.2)	0.9 (0.5-1.4)
5-7 drink/day	0.5 (0.4-0.6)	0.7 (0.5-1.0)	0.7 (0.6-0.9)	0.9 (0.6-1.2)
$\geq$ 8 drink/day	0.9 (0.6-1.2)	1.3 (0.9-1.9)	0.7 (0.5-1.0)	0.7 (0.5-1.1)
Time spent for high intensity exercise (1 SD change)	0.9 (0.8-1.0)	1.0 (0.9-1.1)	0.9 (0.8-1.0)	0.9 (0.8-1.1)
Time spent for moderate intensity exercise (1 SD change)	0.8 (0.7-0.9)	0.8 (0.7-0.9)	0.9 (0.8-0.97)	0.9 (0.8-1.0)
Time spent for walking (1 SD change)	1.0 (0.9-1.1)	0.9 (0.8-1.0)	0.9 (0.8-0.99)	0.9(0.8-1.0)
Total energy intake (1 SD change)	0.8 (0.7-0.9)	1.0 (0.8-1.1)	1.0 (0.9-1.1)	1.1 (0.9-1.2)
Carbohydrate intake (1 SD change)	1.4 (1.2-1.6)	1.0 (0.8-1.2)	1.2 (1.04-1.3)	0.9 (0.7-1.1)
Fat intake (1 SD change)	0.6 (0.6-0.7)	1.0 (0.8-1.2)	0.8 (0.7-0.9)	0.9 (0.7-1.1)
Protein intake (1 SD change)	0.8 (0.7-0.9)	0.9 (0.8-1.0)	0.8 (0.7-0.9)	0.9 (0.8-1.0)

MONW, metabolically obese with normal weight (i.e. those having MS and BMI < 25 kg/m^2); MHNW, metabolically healthy and normal weight; MOO, metabolically obese and obese; MHO, metabolically healthy, but obese (i.e. those not with MS and BMI $\geq$ 25 kg/m^2)
KNHANES: Korean National Health and Nutrition Examination Survey
*Odds ratio and 95% confidence interval adjusted for every other factor in the table

hol consumption, and never-smoking, seem to contribute to a more desirable metabolic status, beyond their influence on odds of obesity. Additionally, older individuals, men, or individuals with low education are more likely to have an undesirable metabolic status and should be the targets of intervention efforts.

AUTHOR DISCLOSURES

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韓國的正常體重代謝性肥胖者(MONW)及肥胖代謝性健康者(MHO)的表現型：特性及健康行為

此研究目的為評估在韓國成年人的'正常體重但代謝性肥胖者(MONW)'及'肥胖但代謝性健康者(MHO)'的表現型盛行率，及確認與兩個表現型相關的特性及健康行為。參與第三次韓國國民健康與營養調查的 5267 名(2227 名男性，3040 名女性)受試者中，MONW 表現型(佔整體的 8.7%，佔正常體重者的 12.7%)是指正常體重(BMI<25)但有代謝症候群(MS)的個體；而 MHO 表現型(佔整體的 15.2%，佔肥胖者的 47.9%)是指肥胖者(BMI≥25)但沒有代謝症候群。MONW 表現型的危險對比值在那些年齡較高，且教育程度較低，有適量飲酒及參與中等強度運動者顯著性較高。MHO 表現型的危險對比值在那些年齡較高、男性且教育程度較低，曾經或目前抽菸者顯著性較低。總之，不管體重狀況，應修正健康行為以預防代謝症候群。

關鍵字：正常體重代謝性肥胖、肥胖代謝性健康、表現型、盛行率、健康行為、韓國人