



Interaction Effect between Weight Perception and Comorbidities on Weight Control Behavior in Overweight and Obese Adults: Is There a Sex Difference?

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We investigated the interaction effect between body weight perception and chronic disease comorbidities on body weight control behavior in overweight/obese Korean adults. We analyzed data from 9,138 overweight/obese adults ≥ 20 yr of age from a nationally representative cross-sectional survey. Multiple logistic regression using an interaction model was performed to estimate the effect of chronic disease comorbidities on weight control behavior regarding weight perception. Adjusted odds ratios for weight control behavior tended to increase significantly with an increasing number of comorbidities in men regardless of weight perception ($P < 0.05$ for trend), suggesting no interaction. Unlike women who perceived their weight accurately, women who under-perceived their weight did not show significant improvements in weight control behavior even with an increasing number of comorbidities. Thus, a significant interaction between weight perception and comorbidities was found only in women ($P = 0.031$ for interaction). The effect of the relationship between accurate weight perception and chronic disease comorbidities on weight control behavior varied by sex. Improving awareness of body image is particularly necessary for overweight and obese women to prevent complications.

Keywords: Comorbidity; Body Image; Weight Perception; Obesity

INTRODUCTION

Obesity is an important risk factor for various diseases, including hypertension, type 2 diabetes, cardiovascular diseases, cancers, and premature death (1, 2). The worldwide prevalence of overweight and obesity in adults has almost doubled in the past three decades, and 35% of adults were overweight or obese in 2008. Overweight and obesity are the fifth and tenth leading risk factors, respectively, for global death and disease burden measured in disability-adjusted life years and are also associated with high health expenditures (3, 4). As the prevalence of obesity in Korea increased rapidly from 13.9% in 1995 to 31.9% in 2011 (5, 6), the prevalence of cardiovascular diseases increased more than two-fold and that of obesity-related cancers, including colorectal and breast cancers, has increased steadily in the past 10 yr (7-9). A 5% weight loss reduces the incidence of cardiovascular disease (10). Therefore, it is necessary for overweight and obese adults to lose weight to prevent such diseases and to reduce socioeconomic burden.

Several ways of losing weight include physical activity, dietary intervention, medications, and surgery. Among these methods, behavior modification through physical activity and dietary intervention is fundamental. Behavior modification is associated

closely with age, sex, socioeconomic status, chronic disease comorbidities, and weight status (11-18). Overweight and obese individuals are motivated to participate in weight management programs by developing an accurate weight perception (13, 18-23). In other words, overweight or obese individuals who under-perceive their weight tend to try less to lose weight and tend to practice unhealthy weight control behaviors, such as fasting, self-induced vomiting, or using laxatives (19-21). Therefore, an accurate weight perception plays an important role in healthy weight control behavior.

As obesity leads to many complications (i.e., cardiovascular disease and stroke) and worsens pre-existing conditions (1, 2), it is particularly important for patients with chronic diseases, such as hypertension and diabetes, to control their weight. A comorbid condition may affect weight control behavior as well. However, previous studies reported inconsistent results regarding weight management tendencies in overweight and obese people. Some studies in Western societies reveal that a diagnosis of hypertension or diabetes is not associated with good weight control behavior and that people without a chronic disease try harder to control their weight than those with a chronic disease (14, 24, 25). In contrast, other studies, both in the United States and Korea, have reported the opposite: patients with chronic

disease tend to control their weight better than those without a chronic disease (13, 26). These conflicting results may have occurred because weight perception was not considered as a principal cause, even though it is probably the most important factor influencing weight control behavior. As precise weight perception has a greater effect on weight control than a comorbidity (14) and these factors are correlated, it is necessary to estimate the interaction effect between weight perception and comorbidities. However, this has not been examined fully in any study.

In addition, women are more sensitive to self-body image and weight management than are men (13). That is, women tend to over-perceive their weight compared with men. This observation may lead to different results between men and women for the relationship between self-perceived weight and weight control behavior and for the interaction effect between weight perception and comorbidity on weight behavior.

The aims of this study were to 1) examine the interaction effect between weight perception and chronic disease comorbidities on weight control behavior in overweight and obese Korean adults and 2) assess the difference between the sexes.

MATERIALS AND METHODS

Study population

This study examined data from the Fourth Korea National Health and Nutrition Examination Survey 2007-2009 (KNHANES IV) conducted by the Korea Centers for Disease Control and Prevention. The KNHANES is a nationally representative cross-sectional survey using a stratified multistage probability sample of Korean civilians. Additional details of the KNHANES are described elsewhere (6).

Of the 24,871 subjects who participated in KNHANES VI, the study population was limited to overweight and obese adults aged ≥ 20 yr (measured body mass index [BMI] ≥ 23.0 kg/m²). We excluded individuals with missing data for BMI, self-perceived weight status, weight control behavior, comorbidity of hypertension or diabetes, socioeconomic status (education, income, and marital status), smoking, or pregnancy status. As a result, the final sample included 9,138 adults (4,306 men and 4,832 women).

Response variables

Participants described their weight control behavior during the past year with the following four answers: "I tried to 1) lose weight, 2) stay at the same weight, 3) gain weight, or 4) do nothing about my weight". Subjects who responded "tried to lose weight" were categorized as those who underwent a weight management program.

Explanatory variables

Heights and weights of the participants were measured using

standardized anthropometric methods. BMI was used to categorize weight status as overweight (23.0-24.9 kg/m²) or obese (≥ 25.0 kg/m²) (27).

Self-reported weight perception and calculated BMIs were used to assess the accuracy of weight perception. Self-reported weight perception was obtained by asking participants if they considered themselves "very thin, slightly thin, ideal, slightly heavy, or very heavy." As we restricted the sample to overweight and obese adults, those who perceived themselves as "very thin, slightly thin, or ideal" were defined as under-perceiving their weight, and those who perceived themselves as "very heavy or slightly heavy" were classified as having an accurate weight perception (28). Participants who self-reported a diagnosis of hypertension or diabetes by a physician were considered to have a comorbid condition and were classified into three groups according to the number of comorbidities (none, one, or two).

Other covariates

Other covariates included age, socioeconomic status, and smoking status. Socioeconomic status was composed of household income (quartile), education level (elementary school or less, middle school, high school, or college and above), and marital status (married and living with a spouse, married and living without a spouse [separated, divorced, or widowed], or unmarried). Smoking status was categorized into current smoker, ex-smoker, or never-smoker.

Statistical analysis

A descriptive analysis was conducted to examine the relationships between the factors of interest and weight perception. Multiple logistic regression models were used to assess the association between weight perception and weight control behavior after adjusting for covariates, including age, household income, education level, marital status, smoking, BMI, and chronic disease comorbidities. An interaction model was used to estimate the effect of chronic disease comorbidities on weight control behavior according to weight perception. An interaction term between weight perception and the number of comorbidities was added to the model. All analyses were performed separately by sex using IBM SPSS Statistics 19.0 (IBM Corp., Armonk, NY, USA), and a *P* value < 0.05 was considered significant. All results are presented using the complex sampling procedures in SPSS to represent the Korean population.

Ethics statement

KNHANES was approved by the institutional review board of the Korea Centers for Disease Control and Prevention (approval number, 2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C). All participants signed and submitted an informed consent form.

RESULTS

Table 1 shows general characteristics of the study population. Among the overweight and obese adults, 59.7% of men and 74.8% of women had an accurate body weight perception, whereas 40.3% of men and 25.2% of women misperceived themselves as underweight relative to their calculated BMIs. The subjects who had an accurate weight perception were younger, more obese, unmarried, had a higher household income and education level, and had better weight control behavior than those who under-perceived their weight. Chronic disease comorbidities were not associated with weight perception in men, but women without a chronic disease appropriately perceived their weight compared with those with a chronic disease.

The unadjusted odds ratios (ORs) for weight control behavior by sex are shown in Table 2. Unadjusted ORs for weight control behavior in both men and women were significantly higher for those who were younger, had a higher household income and education level, and were unmarried, with a linear trend ($P < 0.05$ for trend). Of the obesity-related variables, BMI had signifi-

cant ORs of 2.68 (95% confidence interval [CI], 2.33-3.09) in men and 1.47 (95% CI, 1.29-1.68) in women. In addition, accurately perceiving one's weight also had significantly higher ORs of 3.48 (95% CI, 3.01-4.03) in men and 4.01 (95% CI, 3.41-4.71) in women, and showed a steeper gradient than that of BMI in both sexes. In contrast, the association between comorbidities and weight control behavior differed between men and women: the number of comorbidities was not associated with weight control behavior in men but had an inverse relationship in women (one comorbidity: OR, 0.65; 95% CI, 0.56-0.75; two: OR, 0.69; 95% CI, 0.53-0.90).

Adjusted ORs were calculated to clarify the associations of weight perception and BMI with weight control behavior (Table 3). BMI still had significant ORs of 2.75 (95% CI, 2.38-3.18) in men and 1.78 (95% CI, 1.54-2.05) in women after adjusting for age, household income, education level, marital status, smoking, and chronic disease comorbidities. However, after adjusting for weight perception, the association between BMI and weight control behavior was weaker than it was in the unadjusted model or the adjusted model that excluded weight percep-

Table 1. General characteristics of the participants according to weight perception

Parameters	Men (n = 4,306)			Women (n = 4,832)		
	Under-perception n = 1,838 (40.3%)	Accurate perception n = 2,468 (59.7%)	P value	Under-perception n = 1,394 (25.2%)	Accurate perception n = 3,438 (74.8%)	P value
Age (yr)	46.7 (0.4)	42.1 (0.3)	< 0.001	59.8 (0.5)	47.2 (0.4)	< 0.001
BMI			< 0.001			< 0.001
Overweight (23.0-24.9 kg/m ²)	68.7 (1.3)	31.3 (1.3)		37.8 (1.3)	62.2 (1.3)	
Obesity (≥ 25 kg/m ²)	19.7 (1.0)	80.3 (1.0)		15.3 (0.7)	84.7 (0.7)	
Household income			< 0.001			< 0.001
1st quartile (lowest)	53.5 (2.4)	46.5 (2.4)		39.3 (1.6)	60.7 (1.6)	
2nd quartile	41.6 (1.8)	58.4 (1.8)		24.0 (1.4)	76.0 (1.4)	
3rd quartile	37.0 (1.5)	63.0 (1.5)		20.4 (1.3)	79.6 (1.3)	
4rd quartile	37.6 (1.6)	62.4 (1.6)		19.4 (1.3)	80.6 (1.3)	
Education			< 0.001			< 0.001
Elementary or less	58.0 (2.2)	42.0 (2.2)		40.3 (1.3)	59.7 (1.3)	
Middle school	45.9 (2.5)	54.1 (2.5)		27.6 (2.1)	72.4 (2.1)	
High school	38.2 (1.4)	61.8 (1.4)		13.6 (1.0)	86.4 (1.0)	
College and above	35.2 (1.5)	64.8 (1.5)		12.9 (1.5)	87.1 (1.5)	
Marital status			0.025			< 0.001
Married & living w/o a spouse	44.3 (3.9)	55.7 (3.9)		39.4 (1.7)	60.6 (1.7)	
Married & living w/ a spouse	41.2 (1.0)	58.8 (1.0)		23.0 (0.8)	77.0 (0.8)	
Unmarried	35.7 (2.0)	64.3 (2.0)		5.5 (1.5)	94.5 (1.5)	
Smoking			0.034			0.812
Current-smoker	38.0 (1.3)	62.0 (1.3)		25.0 (3.3)	75.0 (3.3)	
Ex-smoker	43.0 (1.5)	57.0 (1.5)		27.7 (4.3)	72.3 (4.3)	
Never-smoker	40.9 (1.9)	59.1 (1.9)		25.1 (0.7)	74.9 (0.7)	
No. Comorbidity of chronic disease*			0.957			< 0.001
None	40.1 (1.0)	59.9 (1.0)		21.9 (0.9)	78.1 (0.9)	
One	40.7 (1.8)	59.3 (1.8)		33.8 (1.5)	66.2 (1.5)	
Two	40.3 (3.8)	59.7 (3.8)		30.9 (2.9)	69.1 (2.9)	
Weight control behaviors			< 0.001			< 0.001
Yes	25.3 (1.1)	74.7 (1.1)		14.6 (0.8)	85.4 (0.8)	
No	54.1 (1.2)	45.9 (1.2)		40.6 (1.2)	59.4 (1.2)	

Values represent weighted percentages or means (standard error) from a complex sampling analysis. *Self-reported as having received a diagnosis of hypertension or diabetes by a physician.

Table 2. Unadjusted odds ratios (95% confidence intervals) for weight control behavior by sex

Variables	Men		Women	
	OR	<i>P</i> _{trend}	OR	<i>P</i> _{trend}
Age		< 0.001		< 0.001
20-39	3.04 (2.25-4.09)		8.37 (6.58-10.65)	
40-49	2.91 (2.16-3.92)		5.70 (4.43-7.33)	
50-59	2.69 (1.96-3.68)		4.90 (3.88-6.20)	
60-69	1.92 (1.39-2.65)		3.07 (2.41-3.92)	
70+	ref		ref	
BMI		< 0.001		< 0.001
Overweight (23.0-24.9 kg/m ²)	ref		ref	
Obesity (≥ 25 kg/m ²)	2.68 (2.33-3.09)		1.47 (1.29-1.68)	
Weight perception		< 0.001		< 0.001
Under-perception	ref		ref	
Accurate perception	3.48 (3.01-4.03)		4.01 (3.41-4.71)	
Household income		< 0.001		< 0.001
1st quartile(lowest)	ref		ref	
2nd quartile	1.47 (1.16-1.86)		1.81 (1.49-2.20)	
3rd quartile	1.50 (1.18-1.92)		2.19 (1.79-2.69)	
4rd quartile	2.09 (1.66-2.65)		2.62 (2.14-3.19)	
Education		< 0.001		< 0.001
Elementary	ref		ref	
Middle	1.81 (1.39-2.37)		2.08 (1.71-2.54)	
High	1.78 (1.42-2.20)		2.74 (2.33-3.22)	
College	2.47(1.99-3.05)		3.45 (2.80-4.25)	
Marital status		0.021		< 0.001
Married living without spouse	ref		ref	
Married living with spouse	1.12 (0.84-1.50)		1.94 (1.64-2.28)	
Unmarried	1.36 (0.99-1.89)		3.99 (2.87-5.55)	
Smoking		< 0.001		0.343
Current-smoker	ref		ref	
Ex-smoker	1.38 (1.19-1.60)		0.81 (0.49-1.33)	
Never-smoker	1.43 (1.20-1.72)		1.08 (0.78-1.51)	
No. of Comorbidities*		0.033		< 0.001
None	ref		ref	
One	1.13 (0.96-1.33)		0.65 (0.56-0.75)	
Two	1.33 (0.96-1.86)		0.69 (0.53-0.90)	

*Self-reported as having received a diagnosis of hypertension or diabetes by a physician.

Table 3. Adjusted odds ratios (95% confidence intervals) for the effects of body mass index (BMI), weight perception, and the number of chronic comorbid conditions on weight control behavior by sex

Variables	Men		Women	
	Model I [†]	Model II [‡]	Model I [†]	Model II [‡]
BMI				
Overweight (23-24.9 kg/m ²)	ref	ref	ref	ref
Obesity (≥ 25 kg/m ²)	2.75 (2.38-3.18)	1.82 (1.54-2.15)	1.78 (1.54-2.05)	1.39 (1.19-1.63)
No. of Comorbidities*				
None	ref	ref	ref	ref
One	1.42 (1.18-1.72)	1.38 (1.14-1.68)	1.26 (1.07-1.49)	1.23 (1.04-1.45)
Two	1.90 (1.34-2.69)	1.84 (1.27-2.66)	1.53 (1.16-2.02)	1.44 (1.09-1.92)
Weight perception				
Under-perception		ref		ref
Accurate-perception		2.49 (2.10-2.96)		2.49 (2.06-3.00)

*Self-reported as having received a diagnosis of hypertension or diabetes by a physician; [†]Adjusted for age, household income, education level, marital status, smoking, BMI, and chronic disease comorbidities; [‡]Additionally adjusted for body weight perception.

tion. Moreover, similar to the unadjusted model, the ORs for weight perception in men (OR, 2.49; 95% CI, 2.10-2.96) and

women (OR, 2.49; 95% CI, 2.06-3.00) were higher than those of BMI (men: OR, 1.82; 95% CI, 1.54-2.15; women: OR, 1.39; 95%

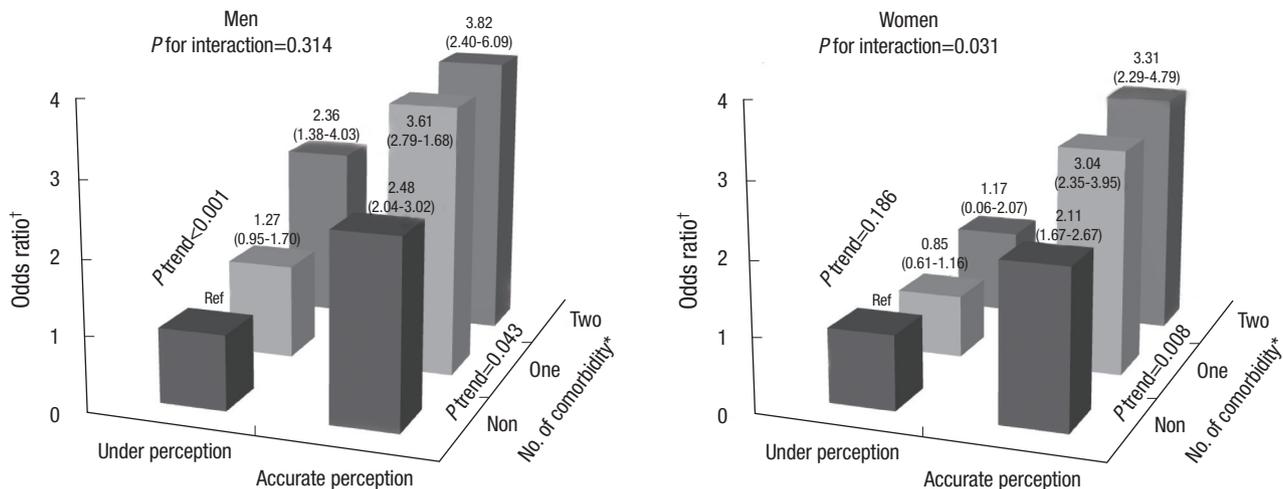


Fig. 1. Adjusted odds ratios (95% confidence intervals) for weight control behavior by weight perception and number of comorbidities. *Self-reported as having received a diagnosis of hypertension or diabetes by a physician; †Adjusted for age, household income, education level, marital status, smoking, body mass index (BMI), and chronic disease comorbidities.

CI, 1.19-1.63). In contrast to the univariate analysis, the number of comorbidities was associated significantly and positively with weight control behavior in both men and women in the multivariate analysis.

The results from the interaction model are shown in Fig. 1. Regardless of weight perception, the adjusted ORs for weight control behavior increased significantly with an increasing number of comorbidities in men ($P < 0.05$ for trend). This significant association was also present in women who perceived their weight accurately. However, the number of comorbidities had no significant effect on weight control behavior in women who under-perceived their weight status. A significant interaction between the number of comorbidities and weight perception was found only in women ($P = 0.031$ for interaction).

DISCUSSION

Our results show that the association between weight control behavior and subjective weight status was stronger than that between weight control behavior and BMI. This finding is consistent with results from the National Health and Nutrition Examination Survey (NHANES), a nationally representative United States survey (14).

Overweight/obese people with hypertension or diabetes have a greater chance of complications, such as cardiovascular disease or stroke, than those without these diseases. Therefore, overweight/obese people with comorbidities should control their weight more strictly. As mentioned previously, many studies have reported the association between a comorbidity and weight control behavior, but they showed conflicting outcomes (13, 14, 24-26). This discrepancy can be explained partially by the temporal relationship between weight control behavior and

comorbidities. In other words, some kinds of chronic diseases develop in obese or overweight people, as they are not interested in weight management or they try to manage their weight to control their chronic condition. An exact causal relationship cannot be determined by cross-sectional studies, and conflicting outcomes may occur. In addition, grasping the key motivating factor for weight management is essential to determine the association between weight control behavior and comorbidities. Because we used a cross-sectional, and not a longitudinal design, the exact causal relationship could not be determined in our study. Even with this limitation, this study is probably more accurate than others, as the key motivating factor of weight perception was the main focus. Previous studies only considered BMI as a main effect, or they did not consider the interaction effect between weight perception and comorbidities. Weight control behavior improved significantly as the number of comorbidities increased in both men and women when we analyzed the data as in previous studies.

However, a sex difference was detected in the effect of accurate weight perception and chronic disease comorbidities on weight control behavior when the interaction model was used. In other words, the adjusted ORs for weight control behavior tended to increase significantly with an increasing number of comorbidities in men regardless of weight perception (P trend < 0.05). Although men tended to under-perceive their weight, those with both hypertension and diabetes showed a similar adjusted OR value of 2.36 for weight control behavior to that of those with accurate weight perception but no comorbidities (adjusted OR, 2.48). However, weight control behavior in women who under-perceived their weight did not improve significantly with an increasing number of comorbidities. The outcome of the interaction effect model also supported a sex dif-

ference in weight control behavior.

These results show that men and women have different motivation sources for weight control. Health and physical appearance are well-known reasons (in this order) for weight control in both sexes. However, a population-based survey in Canada evaluating weight management motivators reported that men control their weight for better health (75%) and appearance (40%). In contrast, the contributing effects of these first (68%) and second reasons (62%) were similar in women (29), which was the same result reported by a study in New Zealand (30). Thus, men with a comorbidity tried to lose weight to improve general health, regardless of weight status, whereas this was not true for women who under-perceived their weight. This difference in perception by sex could be a reason for the conflicting results in previous studies.

Korean women have a 1.1-fold higher mortality rate than that of men, and a higher proportion of women die from circulatory diseases (31). Therefore, it is important for women to manage traditional risk factors, including smoking, hypercholesterolemia, obesity, diabetes, and hypertension, more strictly to prevent cardiovascular diseases. However, women being treated for hypertension, diabetes, or hypercholesterolemia show consistently lower control rates than men, based on the KNHANES results (6). According to studies using NHANES data, women are less likely to be treated or to control hypercholesterolemia and, among those being treated for hypertension, less likely to achieve the recommended blood pressure goals compared with men (32, 33). These sex disparities associated with controlling cardiovascular disease risk factors are also observed in patients with diabetes (34). Therefore, additional efforts may be needed to achieve therapeutic goals for women with comorbidities.

Obesity is a main risk factor for cardiovascular disease in women who poorly manage their comorbid condition, and health outcomes can worsen as weight control fails. Women had twice as high population-attributable risks (PARs) for obesity than those of men in a study on trends in cardiovascular disease PARs using the Atherosclerosis Risk in Communities (ARIC) data, although the differences between the sexes decreased gradually from the late 1980s to the late 1990s (35). Improving awareness of self-body image is a top priority to prevent newly developing and progressing cardiovascular disease, as more than one-fourth of overweight/obese women did not perceive their weight correctly. This is because accurate weight perception is of paramount importance for weight control behavior. In addition, this could have synergistic effects on hypertension, diabetes, and hyperlipidemia management.

This study had some limitations that should be discussed. First, the cross-sectional study design of the KNHANES could not determine the causal relationship between weight perception and weight control behavior. Second, weight control behavior and disease status were self-reported; thus, there could have

been recall bias or misclassification bias. Third, the degree of weight perception accuracy is influenced by sex in social and cultural contexts. In other words, women are more likely to over-perceive their weight compared with men. In this study, the proportion of men who under-perceived their weight (40.0%) was much higher than that of women (25.2%). Therefore, we stratified by sex to overcome this difference. Fourth, body satisfaction differs with race, as sociocultural factors play an important role in the development of body image (36). Thus, our results should be interpreted cautiously. Fifth, basically, KNHANES was implemented without applying overweight criteria. This study included overweight participants ($23.0 \leq \text{BMI} < 25.0$) for the following reasons. WHO recommended a BMI cut-off point of 23.0 for Asian populations when determining overweight and obesity, and the WHO Expert Consultation also identified it as one of the potential public health action points (27, 37). In accordance with these public perspectives, it is necessary for overweight people, especially those with hypertension or diabetes, to control their weight more than people with ideal weight in order to prevent any complications. A pooled analysis of the Asian Cohort Consortium, including more than 20 perspective cohorts representing Korea as well, observed that the mortality rate of overall cardiovascular disease, coronary heart disease, and stroke was higher for BMI range 22.5-24.9 than 20.0-22.4 (38). In addition, the 2014 Clinical Practice Guidelines for overweight and obesity by Korean Endocrine Society and Korean Society for the Study of Obesity also reported that comprehensive lifestyle interventions are recommended for overweight populations with comorbidities (39).

Despite these limitations, the major strength of this study is investigating the effects of chronic disease comorbidities on weight control behavior. Previous studies have also examined this relationship, but used BMI instead of weight perception as a weight control motivator. In addition, we assessed the interaction between chronic disease and accurate weight perception and found sex disparities in the triggers used by overweight and obese people to practice weight control. The KNHANES data used in this study were collected from a nationally representative survey to assess the health and nutrition status of the Korean population, and anthropometry was measured directly using a standardized protocol. Therefore, our results are reliable and can be applied to the general Korean population.

In conclusion, perceived weight plays a more important role than does objective obesity in weight control behavior. Accurate weight perception differs between the sexes and affects weight control behavior. Therefore, improving body image awareness may help improve the health of overweight/obese people. Women with chronic diseases who need to manage their weight can increase their motivation to practice weight control by improving body image accuracy.

DISCLOSURE

All of the authors have no potential conflicts of interest or financial ties to disclose.

AUTHOR CONTRIBUTION

Conception and coordination of the study: Hwang JH, Park SW. Design of ethical issues: Hwang JH, Ryu DH, Park SW. Data review: Hwang JH. Statistical analysis: Hwang JH. Manuscript preparation: Hwang JH, Ryu DH. Critical review of the manuscript: Park SW. Manuscript approval: all authors.

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