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Weight control success and depression by gender with respect to weight control behaviors

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A B S T R A C T

Background/Objective: There are many methods for weight loss and they vary among people. Some are yet to be proven as appropriate regarding its physical or mental side effect. The aim of this study was to investigate the relationship between weight control success and depression by weight control behaviors (WCB) dividing them into appropriate and inappropriate.

Subjects/Methods: We used data from the 2016 Korea National Health and Nutrition Examination Survey (KNHANES). A total of 4506 people were included in the study. The depression was measured by the 9-item Patient Health Questionnaire as a dependent variable. Using multiple regression analysis to determine the association between weight control success and depression with appropriate and inappropriate WCB, in men and women, separately.

Results: We found that appropriate WCB was associated with decreased depression in women who had both success and fail (success: $\beta = -0.16$, S.E = 0.50, $p < .001$; fail: $\beta = -0.09$, S.E = 0.04, $p = 0.04$), whereas inappropriate WCB increased depression in men regardless of success or failure at weight control (success: $\beta = 0.41$, $p = 0.02$; fail: $\beta = 0.22$, $p = 0.02$). Thus, women who are successful at weight control and use appropriate WCB are more likely to have a decrease in depressive symptoms. However, men are most affected by using inappropriate WCB and can have an increase in depressive symptoms as a result.

Conclusion: The findings have implications for encouraging the use of appropriate WCB for those attempting to control weight, especially in women.

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Introduction

Obesity is a health concern that has increased in modern society over the years; the prevalence of obesity-related chronic diseases such as diabetes and cardiovascular disease has increased as well. In South Korea, prevalence of obesity has been continuously increasing, and it appeared to be 34.8% in 2016 [1]. Accordingly, dieting has become a common phenomenon in modern society [2]. Owing to the coexistence of environmental factors that cause obesity and the media depictions of ideal body shape, the ratio of dieting people is increasing [3,4]. Health problems and attractiveness are two

major reasons why people go on a diet among many other reasons such as self-esteem issues, fear, enjoyment, and competition [5–7].

Weight control plays an important role in prevention of illness and improvement of health status [8]. However, weight control has more significance to the majority of people as a means of improving appearance than a means of solving health problems [6,8,9]. As South Korea has undergone industrialized growth and informatization over the past decades, a vast amount of information that puts pressure on people to have a slender body has flowed through the global media and the internet [3,4,10]. Even those who do not need a diet are often tempted to go on one because of a misperception between their actual body shape and subjective body shape [6,9], which leads to various adverse effects such as excessive exercise, diet problems, drop in self-esteem, and depression [11–14]. In particular, weight loss attempts have been found to be significantly associated with increased depression [15–17]. Accordingly, depression can lead to potential health problems that can be detrimental

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to one's health because of irregular eating, binge eating, anorexia, drug abuse, or inappropriate weight control behaviors [16,17].

In South Korea, 12-month rate of major depression was revealed to be about 2.5% in the most recent national wide survey conducted in 2006–2007 [18]. Furthermore, one of major leading causes of death in South Korea, suicide, is a possible consequence of depressive disorder. According to the Organization for Economic Cooperation and Development (OECD), South Korea is the 10th highest rate of suicidal death in the world as well as the highest rate for an OECD member state.

Methods for weight control are associated with individuals' depression [15–17], and there are many methods for weight loss and they change with social trends, vary among people, and some of the methods are yet to be proven as appropriate [19,20]. Even though some methods were revealed to have physical or mental side effects, people still use them as a way to lose weight [21,22]. In addition, there are differences between men and women in weight control behaviors and motivations [7,23]. Therefore, the aim of the present study was to investigate the association between weight control success and depression by weight control behaviors (WCB), dividing WCB into those that are appropriate versus inappropriate by referring previous studies [3,11,15,24], and using nationally representative health data analyzed separately by gender. Additionally, the study aimed to find which specific or combinations of WCB increased depression among male and female participants.

Methods

Data and population

We used data from a cross-sectional and nationally representative survey conducted by the Korea Centers for Disease Control and Prevention; 2016 Korea National Health and Nutrition Examination Survey (KNHANES) for the study. The study was about general population and compared population between who controlled weight and who did not, with the association to depression measured by PHQ-9 scores. The baseline study population included 8150 people. Among them, the number of individuals whose age were 20 or older was 6152. After excluding individuals with missing data in the 9-item Patient Health Questionnaire (PHQ-9) (n = −456), WCB (n = −331), household income (n = −13), body mass index (BMI) (n = −57), physical activity (n = −12), and daily caloric intake (n = −777) our total sample size comprised 4506 individuals.

Study variables

Depression was the main dependent variable in this study, which was measured by the PHQ-9. The PHQ-9 has been a useful instrument for diagnosing depression and other mental disorders according to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) criteria, and its validity, reliability, and utility have been proven in many studies [25,26]. The PHQ-9 consists of 9 questions about depression-related symptoms to which individuals respond using a 4-point scale according to "Over the last 2 weeks, how often have you been bothered by any of the following problems?" As a severity of depression measure, responses range from 0 (*not at all*) to 3 (*nearly every day*) points, with a total PHQ-9 score ranging from 0 to 27 points. In this study the PHQ-9 was used as a continuous measure with higher scores indicating more depressive symptoms.

The key independent variable was weight control success attempted by appropriate or inappropriate weight control behaviors (WCB). Participants were asked the following multi-part question. "Please indicate which methods you have used to reduce or maintain your weight over the past year, with the following activities listed: (1) exercising, (2) fasting at least 24 h (or regarded

as 'intermittent fasting' and 'alternate-day fasting'), (3) adjusting diet (or eating less), (4) skipping meals, (5) taking nonprescription diet pills, (6) taking prescription diet pills, (7) taking oriental medicine, (8) taking functional food, (9) eating only one food (known as 'crash diet' or 'mono diet,' or called 'one-food-diet' in Korea)." By referring to previous studies [3,11,15,24], we classified the use of "inappropriate WCB" if participants indicated any one of numbers (2), (4), (5), or (9), and classified the use of "appropriate WCB" if participants did not indicate the use of numbers (2), (4), (5), and (9).

Furthermore, several control variables including sociodemographic, economic, and health factors were assessed. Sociodemographic variables comprised age (20–29, 30–39, 40–49, 50–59, or ≥60 years), marital status (married, or unmarried), and living arrangement (alone, or not alone). Economic variables included household income (low, mid-low, mid-high, or high based on 1 st through 4th quartile) and economic activity (employed, or unemployed). Health variables included BMI (weight (kg)/height$(m)^2$; underweight or normal: BMI < 25; overweight: $25 \leq BMI \leq 29.9$; obesity: $30 \leq BMI$) [27], hypertension (normal, prehypertension, or hypertension), aerobic physical activity practice rate [28], childbirth experience (only for women; normal birth, stillbirth or abortion, or none), depression diagnosis (diagnosed, or not diagnosed by a doctor), and body misperception between actual body weight and subjective body image (overestimation, right recognition, or underestimation). A nutritional variable included the caloric intake (calculated as the average number of kcals consumed per day). Participants were also asked, "How often do you feel stress in your daily life?" to assess stress perception level. We classified the answers of "extremely" and "highly" as "high," and the answers of "less" and "little" as "low." The number of chronic diseases were assessed (0, 1, and ≥2) from a list of 24 chronic diseases investigated in KNHANES [28]. Difficulty with activities of daily living was answered "No" or "Yes" in response to the question "Are you currently limited in your daily life and social activities due to health problems or physical or mental disabilities?". Body misperception was defined difference between individual's BMI categories and subjective perception on body weight which was able to assess through the question: "How do you describe your weight?" (possible answers were "very underweight", "slightly underweight", "normal", "slightly overweight", and "very overweight") [29]. All control variables except for caloric intake were treated as categorical variables. Any multicollinearity was not shown among all independent variables (Supplementary Table 1).

Statistical analysis

For all statistical analyses, we applied sampling weight variables provided by KNHANES to improve the representability and accuracy of estimates [28,30]. Firstly, univariate analysis was performed for the mean PHQ-9 score, medians, and inter-quartile ranges (IQR) for each variable. We measured medians and IQR as an interval estimate instead of standard deviation, because the PHQ-9 score does not confirm to a normal distribution due to its skewness [31]. Thereafter, a log-transformation of PHQ-9 was conducted to improve its normality (Supplementary Fig. 1). Additionally, t-tests were performed to determine the frequencies and percentages of the study sample for each variable. Accordingly, to analyze the association between weight control success stratified by appropriate or inappropriate WCB and log-transformed PHQ-9, we performed multiple regression analysis after adjusting for control variables. Finally, two sets of subgroup analyses were performed adjusting for all control variables; the first subgroup analyses by age, marital status, and the number of chronic diseases, and the second subgroup analyses by each weight control method and its combinations. All statistical

analyses were performed by using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA) and the significance level was set at 0.05.

Results

Table 1 includes the general characteristics of the study sample (male: 1783, female: 2723) after excluding missing values. Of the male sample, the mean PHQ-9 score of 344 (19.3%) men who had weight control success with appropriate WCB was 1.82. The mean score of 27 (1.5%) men who had successful weight control with inappropriate WCB was 3.56. 541 (30.3%) men who did not have successful weight control with appropriate WCB had a mean score of 1.86, and 90 (5.0%) men who did not have successful weight control with inappropriate WCB had a mean score of 2.83. Lastly, 781 (43.8%) men who did not try weight control had a mean score of 2.02. Of the female sample, the mean PHQ-9 score of 529 (19.4%) women who had successful weight control with appropriate WCB was 2.50, while 43 (1.6%) women who had successful weight control with inappropriate WCB had a mean score of 3.98. 985 (36.2%) women who did not have successful weight control with appropriate WCB had a mean score of 2.88, and 257 (9.4%) women who did not have successful weight control with inappropriate WCB had a mean score of 3.82. Lastly, the mean score of 909 (33.4%) women who did not try weight control was 3.47.

Table 2 includes the results of the multiple regression model analyzing the factors associated with depression as measured by the PHQ-9. Concerning males' successful weight control with WCB as the main variables of interest, those who tried weight control with inappropriate WCB had higher PHQ-9 scores compared to those who did not try weight control (success: $\beta = 0.41$, S.E = 0.17, $p = 0.02$; fail: $\beta = 0.22$, S.E = 0.09, $p = 0.02$). For women, however, those who had weight control with appropriate WCB yielded lower PHQ-9 scores no matter they had success or fail (success: $\beta = -0.16$, S.E = 0.50, $p < .001$; fail: $\beta = -0.09$, S.E = 0.04, $p = 0.04$), compared to those who did not try weight control.

Table 3 presents the results of the multiple regression analyzing the association between depression and successful weight control with WCB stratified individuals' characteristics by BMI, depression diagnosis, and the number of chronic diseases in men and women separately. Successful weight control with appropriate WCB significantly decreased depression in women who were underweight or had a normal BMI ($\beta = -0.19$, $p < 0.001$), and even obese women who did not have successful weight control but had tried appropriate WCB had decreased depression ($\beta = -0.41$, $p = <0.001$). Regarding men who had been diagnosed with depression by a doctor, inappropriate WCB was associated with increased depression even though they had succeeded in controlling their weight ($\beta = 1.92$, $p = 0.02$). Additionally, men with chronic disease(s) had increased depression when using inappropriate WCB even though they succeeded at weight control (1 chronic disease $\beta = 0.59$, $p = 0.01$; 2 or more chronic diseases $\beta = 1.50$, $p < .001$).

Fig. 1 illustrates the results of the regression analysis of PHQ-9 scores and success with weight control methods with its specific weight control methods or its combinations by gender. Men with inappropriate WCB had increased depression whether they succeeded ($n = 27$, $\beta = 0.41$, $p = 0.02$) or not ($n = 90$, $\beta = 0.22$, $p = 0.02$) compared to men who did not try weight control. In addition, men who failed at skipping meals ($n = 71$, $\beta = 0.29$, $p = 0.01$), and at exercising along with skipping meals ($n = 55$, $\beta = 0.30$, $p = 0.01$), had increased depression. With regard to females, women who succeeded at weight control with appropriate WCB had decreased depression ($n = 529$, $\beta = -0.16$, $p < 0.001$). More specifically, exercising ($n = 354$, $\beta = -0.19$, $p < 0.001$), adjusting one's diet ($n = 372$, $\beta = -0.17$, $p < 0.001$), adjusting diet along with exercising ($n = 206$, $\beta = -0.20$, $p < 0.001$), having functional food ($n = 31$, $\beta = -0.42$,

$p < 0.001$), and having functional food along with exercising ($n = 18$, $\beta = -0.50$, $p = 0.01$) were associated with decreased depression. Additionally, women who failed at weight control with exercising had lower depression ($n = 685$, $\beta = -0.13$, $p = 0.01$), whereas using diet pills increased depression when women failed at weight control ($n = 39$, $\beta = 0.44$, $p < 0.001$).

Discussion

As the main findings of this study, men were more likely to have the association between increased depression and inappropriate weight control whether they succeeded or not, and women were more likely to have the association between decreased depression and appropriate weight control whether they succeeded or not. Its associations were higher when both men and women succeeded controlling weight. Moreover, the association was identified to have significance in both men and women in association with BMI, depression diagnose, and the number of chronic disease. In addition, successful weight control according to some specific WCB was associated with an increase or decrease in depression compared to not trying weight control.

For men, the increased depression could be attributed to dissatisfaction caused by inappropriate WCB such as not being able to eat what they want to eat. However, because women tend to experience greater pressure to improve their appearance by controlling weight than not eating what they want to eat [7,23], inappropriate WCB was not significantly related with depression, rather successful weight control with appropriate WCB was associated with decreased depression.

In addition, the above results are shown in the age subgroup analysis as well. For underweight or normal weight women, appropriate WCB was important in reducing depression with successful weight control. Even though they may not need to lose weight, they would have gained some health benefits by appropriate methods, such as exercise or regular and proper eating habits [7,16]. In men who were diagnosed with depression or had chronic disease(s), appropriate WCB was not significant with depression changing, but inappropriate WCB was highly significant in increasing depression. In other words, men who were mentally or physically challenged were more vulnerable to inappropriate WCB having an effect on their mental health, such as depression.

The association between inappropriate WCB and increased depression in men was also shown in consideration of some specific weight control methods. Weight control failure with skipping meals was associated with increased depression in men. This result is consistent with previous studies indicating skipping meals affects mental health, especially depression [32].

For women, successful weight control was associated with decreased depression with the enactment of certain appropriate WCB such as exercise, adjusting diet, and having functional food. Exercise requires the person who is attempting to control their weight to be patient, but it is the healthiest way to control weight [33]. Additionally, research has shown that physical exercise contributes to reducing depressive symptoms [2,15,34], which is consistent with the finding in our study. Even if women did not achieve successful weight control by exercising, depression still decreased and this might be the result of personal satisfaction or health benefits gained from physical activity.

Women adjusting their diet as a WCB was also shown to be beneficial to mental health when succeeding at weight control. A proper and nutritionally well-balanced diet is a well-known weight control method, as it not only makes people lose weight in the long-term but also has many health benefits [35]. However, inappropriate WCB such as skipping meals, fasting for a long period, or

Table 1
The general characteristics of the study poulation.

Variables	Men					Women				
	N	% (weighted)/SD	PHQ-9			N	% (weighted)/SD	PHQ-9		
			Mean	Median (IQR)	P-value			Mean	Median (IQR)	P-value
Weight control										
Success										
Appropriate	344	19.3	1.82	1 (3)	0.007	529	19.4	2.50	1 (4)	0.021
Inappropriate	27	1.5	3.56	2 (4.5)		43	1.6	3.98	3 (5)	
Fail										
Appropriate	541	30.3	1.86	1 (3)		985	36.2	2.88	2 (4)	
Inappropriate	90	5.0	2.83	2 (4)		257	9.4	3.82	2 (5)	
Not tried	781	43.8	2.02	1 (3)		909	33.4	3.47	2 (5)	
Age (years)										
20–29	178	10.0	2.36	1 (3)	0.065	289	10.6	3.80	3 (5)	<.001
30–39	304	17.0	2.27	1 (3)		529	19.4	3.30	2 (3)	
40–49	350	19.6	1.90	1 (2)		523	19.2	2.43	1 (4)	
50–59	301	16.9	1.81	1 (3)		509	18.7	2.70	1 (3)	
60~	650	36.5	1.92	1 (3)		873	32.1	3.42	2 (5)	
Marital status										
Married	1472	82.6	1.84	1 (3)	0.002	2392	87.8	3.02	3 (4)	0.179
Unmarried	311	17.4	2.76	1 (3)		331	12.2	3.76	2 (4)	
Living arrangement										
Alone	173	9.7	2.94	1 (4)	0.022	323	11.9	4.03	2 (6)	0.072
Not alone	1610	90.3	1.90	1 (3)		2400	88.1	2.99	2 (4)	
Household income										
Low	311	17.4	3.03	1 (4)	<.001	532	19.5	4.41	3 (6)	<.001
Middle-low	431	24.2	2.12	1 (3)		667	24.5	3.09	2 (4)	
Middle-high	492	27.6	1.59	1 (2)		739	27.1	2.91	2 (4)	
High	549	30.8	1.68	1 (2)		785	28.8	2.42	1 (4)	
Economic activity										
Employed	1,295	72.6	1.78	1 (3)	0.117	1345	49.4	2.71	1 (4)	0.038
Unemployed	488	27.4	2.59	1 (3)		1378	50.6	3.50	2 (5)	
BMI										
Underweight or Normal	990	55.5	2.02	1 (3)	0.057	1843	67.7	3.00	2 (4)	0.169
Overweight	694	38.9	1.98	1 (3)		727	26.7	3.40	2 (5)	
Obese	99	5.6	1.94	1 (3)		153	5.6	2.99	2 (4)	
Physical activity										
Yes	856	48.0	1.95	1 (3)	0.955	1159	42.6	2.96	2 (4)	0.507
No	927	52.0	2.05	1 (3)		1564	57.4	3.22	2 (4)	
Childbirth experience										
Normal birth	–	–	–	–		2295	84.3	2.97	2 (4)	<.001
Stillbirth or abortion	–	–	–	–		61	2.2	5.82	4 (8)	
None	–	–	–	–		367	13.5	3.50	3 (4)	
Depression diagnosis										
Diagnosed	42	2.4	6.31	4 (8)	<.001	178	6.5	7.42	6 (9)	<.001
Not diagnosed	1741	97.6	1.89	1 (3)		2545	93.5	2.81	2 (4)	
Stress perception level										
High	412	23.1	3.94	3 (4)	<.001	772	28.4	5.70	4 (6)	<.001
Low	1371	76.9	1.42	0 (2)		1951	71.6	2.08	1 (3)	
Number of chronic diseases										
0	1005	56.4	1.77	1 (3)	0.001	1473	54.1	2.65	2 (4)	<.001
1	387	21.7	1.88	1 (3)		497	18.3	2.77	2 (4)	
≥2	391	21.9	2.70	1 (4)		753	27.7	4.24	2 (6)	
Difficulty with ADLs										
No	1647	92.4	1.74	1 (3)	<.001	2476	90.9	2.71	1.5 (4)	<.001
Yes	136	7.6	5.12	3 (7)		247	9.1	7.14	6 (9)	
Body weight perception										0.039
Overestimate	215	12.1	2.35	1 (4)	0.807	775	28.5	3.47	2 (5)	
Accurate	1127	63.2	1.97	1 (3)		1604	58.9	2.82	2 (4)	
Underestimate	441	24.7	1.90	2 (5)		344	12.6	3.64	2 (5)	
Caloric intake[a]	2332	±951			0.626	1685	±701			0.876
Total	1783	100.00	2.00	2 (1)		2723	100.00	3.11	2 (4)	

PHQ-9, the 9-item Patient Health Questionnaire, SD, standard deviation, IQR, interquartile range, BMI, body mass index, ADLs, activities of daily living.

[a] Mean and SD of the continuous independent variables in this study.

mono-diet were not associated with successful weight control and depression in women.

Fasting for at least 24 h, or "intermittent fasting" and "alternate-day fasting," was regarded as inappropriate WCB and not statistically significant with depression in our study. However, recent studies have revealed such methods to be effective for weight loss in a short period of time [36,37] and to reduce some health risk factors such as fat mass, low-density lipoprotein choles-terol, and triglycerides [38]. On the other hand, studies indicate that intermittent fasting could also affect risk factors for some diseases [39] and may be harmful in vulnerable populations such as children, the elderly, or persons who are underweight [40]. Therefore, it is uncertain whether intermittent fasting is an appropriate WCB, and people who want to remain healthy while attempting to lose weight need to do so with caution.

Table 2
The results of multiple regression analysis to investigate the association between PHQ-9 and weight control success stratified by weight control behavior and gender.

Variables	Men			Women		
	Log-transformed PHQ-9			Log-transformed PHQ-9		
	β	S.E.	P-value	β	S.E.	P-value
Weight control						
Success						
Appropriate	0.04	0.05	0.46	−0.16	0.05	<.001
Inappropriate	0.41	0.17	0.02	−0.05	0.15	0.72
Fail						
Appropriate	0.02	0.05	0.67	−0.09	0.04	0.04
Inappropriate	0.22	0.09	0.02	0.05	0.06	0.39
Not tried	Ref.	–	–	Ref.	–	–
Age						
20–29	0.00	0.10	1.00	0.43	0.10	<.001
30–39	0.15	0.07	0.05	0.36	0.06	<.001
40–49	0.07	0.07	0.31	0.14	0.06	0.02
50–59	0.03	0.06	0.66	0.11	0.06	0.06
≥60	Ref.	–	–	Ref.	–	–
Marital status						
Married	Ref.	–	–	Ref.	–	–
Unmarried	0.27	0.08	0.00	0.06	0.11	0.59
Living arrangement						
Alone	0.07	0.08	0.36	0.09	0.05	0.09
Not alone	Ref.	–	–	Ref.	–	–
Household income						
Low	0.16	0.08	0.04	0.13	0.06	0.04
Middle-low	0.10	0.05	0.07	0.04	0.05	0.35
Middle-high	−0.04	0.05	0.40	0.06	0.04	0.15
High	Ref.	–	–	Ref.	–	–
Economic activity						
Employed	0.00	0.06	0.93	-0.03	0.03	0.30
Unemployed	Ref.	–	–	Ref.	–	–
BMI						
Underweight	−0.16	0.21	0.44	-0.14	0.11	0.21
Normal	Ref.	–	–	Ref.	–	–
Overweight	−0.20	0.06	0.00	−0.11	0.09	0.20
Obese	−0.29	0.08	0.00	−0.16	0.10	0.11
Physical activity						
Yes	Ref.	–	–	Ref.	–	–
No	−0.02	0.04	0.60	−0.01	0.03	0.75
Childbirth experience						
Normal birth	–	–	–	0.06	0.10	0.57
Stillbirth or abortion	–	–	–	0.27	0.11	0.01
None	–	–	–	Ref.	–	–
Depression diagnosis						
Diagnosed	Ref.	–	–	Ref.	–	–
Not diagnosed	−0.39	0.14	0.00	−0.47	0.08	<.001
Stress perception level						
High	Ref.	–	–	Ref.	–	–
Low	−0.64	0.05	<.001	−0.63	0.03	<.001
Number of chronic diseases						
0	Ref.	–	–	Ref.	–	–
1	0.12	0.05	0.02	0.06	0.05	0.23
≥2	0.21	0.06	0.00	0.26	0.05	<.001
Difficulty with ADLs						
No	Ref.	–	–	Ref.	–	–
Yes	0.51	0.10	<.001	0.66	0.06	<.001
Body weight perception						
Overestimate	0.02	0.10	0.87	0.07	0.07	0.30
Accurate	Ref.	–	–	Ref.	–	–
Underestimate	−0.19	0.06	0.00	−0.08	0.08	0.31
Caloric intake (per 1,000 Kcal increase)	0.03	0.02	0.11	0.02	0.02	0.28

PHQ-9, the 9-item Patient Health Questionnaire, S.E., standard error, BMI, body mass index, ADLs, activities of daily living.

Although the definition of functional food is varied and uncertain [41], it was related to depressive symptoms in a previous study [42]. With consistency, our study showed decreased depression in women who had functional food and had successful weight control, but it was not significant in men. This result may due to restriction of caloric intake [43]. Because losing weight is considerably associated with the amount of caloric intake, men who are trying to lose weight inhibit carbohydrate food intake such as rice and bread, which are two main features of meals of many people. Accordingly,

nutrients that are not able to be supplied by such meals are supplemented with functional foods, and therefore men may experience some stress when food intake is suppressed [42].

Our study results also showed that men were less likely than women to try to control their weight in inappropriate ways. This difference between men and women may contribute to how much they consider exercise or proper diet as a means to weight loss [7,23]. Therefore, consistent with previous studies [3,6,8,20,34], the results suggest that men take improvement of health or satisfac-

Table 3
The results of subgroup analysis of PHQ-9 to weight control success stratified by age, BMI, depression diagnosis, and the number of chronic diseases by gender.[a]

Variables	Weight control												Not tried
	Success						Fail						
	Appropriate			Inappropriate			Appropriate			Inappropriate			
	β	S.E.	P-value	β	S.E.	P-value	β	S.E.	P-value	β	S.E.	P-value	β
Men													
BMI													
Underweight or Normal	−0.04	0.07	0.59	0.52	0.25	0.04	−0.02	0.07	0.77	0.31	0.20	0.12	ref.
Overweight	0.22	0.09	0.01	0.22	0.22	0.32	0.07	0.07	0.36	0.33	0.12	<.001	ref.
Obese	−0.29	0.31	0.36	0.46	0.70	0.51	0.19	0.15	0.21	-0.03	0.28	0.91	ref.
Depression diagnosis													
Diagnosed	0.69	0.66	0.31	1.92	0.81	0.02	1.14	0.45	0.02	-0.17	0.46	0.72	ref.
Not diagnosed	0.04	0.05	0.42	0.40	0.17	0.02	0.01	0.05	0.88	0.25	0.09	0.01	ref.
Number of chronic diseases													
0	−0.02	0.07	0.82	0.31	0.18	0.10	−0.01	0.06	0.82	0.19	0.12	0.11	ref.
1	0.09	0.11	0.43	0.59	0.21	0.01	−0.01	0.09	0.93	0.31	0.18	0.08	ref.
≥2	0.16	0.11	0.16	1.50	0.23	<.001	0.21	0.11	0.05	0.40	0.26	0.13	ref.
Women													
BMI													
Underweight or Normal	−0.19	0.05	<.001	0.01	0.16	0.95	−0.05	0.05	0.36	0.09	0.07	0.20	ref.
Overweight	−0.04	0.12	0.73	0.05	0.34	0.88	−0.08	0.08	0.32	0.10	0.11	0.38	ref.
Obese	0.02	0.25	0.94	-0.85	0.23	<.001	−0.41	0.14	<.001	-0.16	0.18	0.38	ref.
Depression diagnosis													
Diagnosed	−0.29	0.22	0.19	−0.33	0.35	0.36	−0.13	0.13	0.32	0.60	0.23	0.01	ref.
Not diagnosed	−0.16	0.05	<.001	−0.06	0.15	0.72	−0.09	0.05	0.05	0.03	0.06	0.60	ref.
Number of chronic diseases													
0	−0.19	0.06	<.001	0.12	0.15	0.45	−-0.06	0.05	0.30	0.05	0.07	0.49	ref.
1	−0.19	0.12	0.11	−0.68	0.26	0.01	−0.22	0.10	0.04	-0.12	0.16	0.46	ref.
≥2	−0.15	0.09	0.11	0.11	0.45	0.80	−0.07	0.08	0.39	0.12	0.15	0.43	ref.

PHQ-9, the 9-item Patient Health Questionnaire, S.E., standard error, BMI, body mass index, ADLs, activities of daily living.

[a] Adjusted by variables including age, marital status, living arrangement, household income, economic activity, BMI, physical activity, childbirth experience, depression diagnosis, stress perception level, number of chronic diseases, difficulty with ADLs, body weight perception, caloric intake.

tion with appropriate WCB more meaningfully than women do. Furthermore, as women are more sensitive to successful weight control, we may infer that the main purpose of healthy behavior is losing weight rather than improving health for women, and previous research supports this idea that women are more sensitive to controlling weight due to pressure about weight in the media [7].

The present study has a number of limitations. First, due to the nature of cross-sectional research we could not exclude a possible bidirectional effect, thus causal relationships between variables cannot be inferred. Second, the survey questions were mostly based on self-report, therefore, there may be bias caused by recalled memories. Third, there were a possibility of sampling bias on the study results which caused by the little number of people who had success weight control with inappropriate methods, in both men and women. This may reduce the representativeness and reliability of the results. However, the results showed the consistency in most of subgroup analyses, showing that weight control success with appropriate methods decreased depression in women but not in men, and weight control failure with inappropriate methods increased depression in men but not in women. Fourth, there are no generally accepted criteria for appropriate or inappropriate weight control methods, thus we categorized them subjectively. However, in doing so we referred to as many previous studies as possible [3,11,15,24]. Fifth, we were not able to consider the frequency and intensity of each specific weight control method, and how consistently people continued to control weight because of limitation of survey information and nature of the cross-sectional study design. Seventh, like some other studies [44–46], our study also showed that the PHQ-9 had a floor effect (i.e., more than 15% having the lowest value [47]); the lowest PHQ-9 score was zero and 36.5% of total sample, 44.8% of the male sample, and 30.9% of the female sample scored zero. In other words, PHQ-9 scores were skewed and did not follow the normal distribution. Therefore, we minimized the irregularity by performing log transformation. Nevertheless, since we still did not have a perfect normal distribution of PHQ-9 scores, our findings are somewhat skewed with low depression scores.

Despite some limitations, our study also has strengths. First, because the data used was based on a nationwide study it can represent the South Korean population. Second, we analyzed WCB by appropriate and inappropriate behaviors with its success or failure in association with depression scored by PHQ-9 which was already tested for its validity, reliability, and utility [25,26]. Further, we also analyzed the association with each individual weight control method or its combination separately by gender. In general, our study confirmed that men and women showed opposite association with appropriate or inappropriate WCB to depression, implying that there may be a possibility of gender difference in attitude towards losing weight. Third, our study could be referred as a premillinary study for more developed study to test whether any specific appropriate or inappropriate weight control affects individuals' mental health.

Conclusion

We identified that weight control success did not lead to decreased depression unconditionally, because we were able to understand the relationship between weight control success with different WCB and depression. Women who are successful at weight control and use appropriate WCB are more likely to have a decrease in depressive symptoms. However, men are most affected by using inappropriate WCB and can have an increase in depressive symptoms as a result, regardless of success or failure at weight control. Therefore, education of appropriate weight control methods is needed for the population. In addition, as the need for an overall social awareness shifts to the importance of weight control, it should be promoted that proper weight control behaviors are important in terms of physical and mental health. In particular,
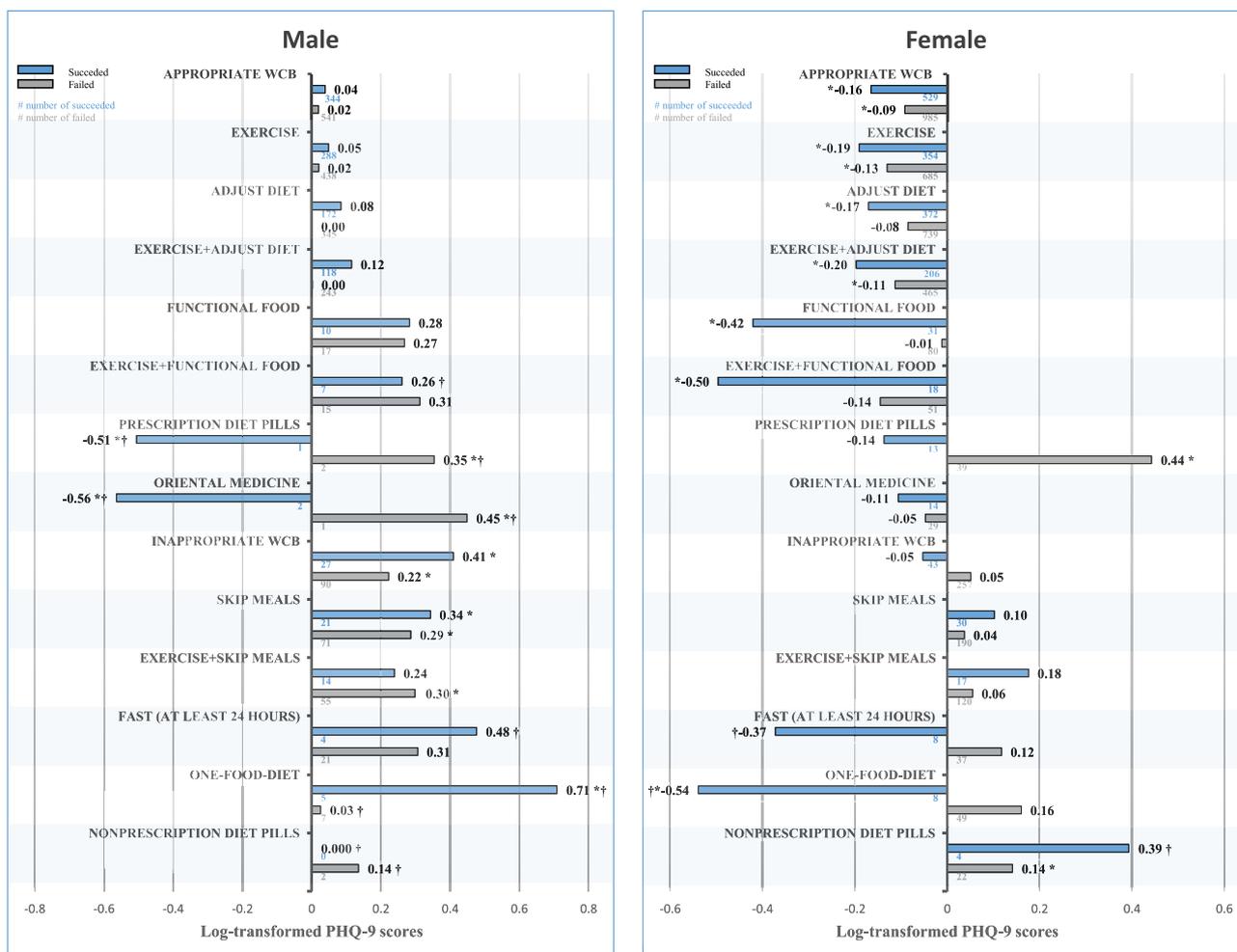
Fig. 1. The results of subgroup analysis of log-transformed PHQ-9 to success with weight control behaviors by gender.[‡]

WCB, Weight Control Behaviors, BMI, body mass index, ADLs, activities of daily living.

[*] Statistically significant results ($p < 0.05$).

[†] Insufficient number of observers ($n < 10$).

[‡] Adjusted by variables including age, marital status, living arrangement, household income, economic activity, BMI, physical activity, childbirth experience, depression diagnosis, stress perception level, number of chronic diseases, difficulty with ADLs, body weight perception, caloric intake.

given that modern society is highly influenced by the media, efforts are needed to encourage appropriate weight control methods.

Author contributions

DWL and ECP designed the research. DWL conducted the research, analyzed data, and wrote the paper. SIJ had primary responsibility for final content. All authors read and approved the final manuscript.

Compliance with ethical standards

Because the KNHANES data does not contain private information and is openly available to researchers in de-identified format, we did not have to address ethical concerns regarding informed consent. Informed consent had been obtained from all participants in the KNHANES.

Conflict of interest

The authors have no conflict of interest to declare.

Acknowledgements

All authors reviewed and approved the final manuscript. DWL, ECP, and SIJ designed the research. DWL wrote the paper and analyzed data. SAL and DWC reviewed and commented about the study design and manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.orcp.2018.11.245.

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