Original Article

Eating behaviors and weight over time in a prospective study: the Healthy Twin Study

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We examined the relationships of combined initial restrained and external/emotional eating with initial BMI and change in weight and these subscales over time. BMI and the Dutch Eating Behavior Questionnaire were twice-measured in 1361 Korean twins and families (482 men, 879 women) over a period of 2.7±0.9 years. Subjects were classified by combination of initial sex-specific restrained and external (or emotional) eating tertiles. Linear mixed models were performed after adjusting for confounders at baseline (household, sibling relations, sex, age, education level, smoking, alcohol use, energy intake, physical activity, and medical history). In adjusted models, initial BMI increased with increasing tertiles of initial restrained eating across initial external/emotional eating tertiles. Weight was less likely to increase over time with increasing tertiles of initial restrained eating in the lowest external eating tertile and middle tertile of emotional eating at baseline. Subscale scores decreased over time with increasing tertiles of corresponding subscales at baseline. These findings suggest that high dietary restraint and external/emotional eating may indicate concurrent high BMI and attenuated weight gain and decreases in corresponding subscales over time.

Key Words: eating behavior, body mass index, body weight changes, weight gain, obesity

INTRODUCTION

Eating behavior, a psychological construct that assesses behavioral control and attitudes toward food and eating,[1] is a complex phenomenon that defies simple description. External and emotional eating is defined as eating in response to external food-related cues and negative emotions, respectively, and restrained eating as a tendency to consciously restrict food intake to achieve weight loss or prevent weight gain.[2] Restrained eating is often associated with tendencies of overeating.[3] In other words, individuals counteract their externally or emotionally induced tendency to overeat by imposing cognitive restraint on their food intake.[2] Therefore, these physiological and psychological relationships between external, emotional, and restrained eating behaviors[4,5] would be involved in concurrent weight status and weight changes over time with positive or negative relationships. In addition, the eating behaviors would be changed over time by the interactions between weight changes, concurrent weight status, and initial levels of those behaviors.

Earlier prospective studies suggest that subscales of initial eating behaviors or the change in subscales are intricately linked to weight status or weight changes.[1,3,6-9] For instance, a study on dieting women showed that increasing levels of dietary restraint moderated weight control by attenuating the positive association between dietary disinhibition and weight.[1] In another study on the general population, high emotional eating was associated with a greater BMI change[7] and it moderated the relation with overconsumption and overweight.[3] However, it is still inexplicit how the inter-relations between eating behavior subscales, such as a combination of restrained eating and external/emotional eating, are related to concurrent weight status, weight changes over time, and the change in eating behavior subscales over time.

In a cross-sectional study using the data of Korean twins and their family members, we found that higher emotional and restrained eating behaviors at initial enrollment were associated with a higher weight gain and BMI from that observed at initial enrollment in 20 year olds.[10] However, we did not examine these relationships in this study regarding the combination of the subscales. We followed the subjects and additionally found a positive association between the change in external eating

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over time and concurrent weight gain, while each eating behavior subscale at baseline did not predict weight changes over time.[9] In the present study, we examined the combined effects of restrained eating and external/emotional eating at initial visit, on concurrent BMI and the change in weights and eating behavior subscales over time in the same cohorts.

MATERIALS AND METHODS

Participants and procedure

The subjects in this study were the participants in the Healthy Twin Study, which has been conducted as a part of the Korean Genomic Epidemiologic Study since 2005. Participants typically included the same-sex twin pairs and their first-degree family members.[9-12] Zygosity of twins was determined using a questionnaire that achieved greater than 90% accuracy and genetic analysis using 16 short tandem repeat markers (15 autosomal-markers and one sex-determining marker, Amp*Fl*STR Identifier Kit; Perkin Elmer, Waltham, MA, USA).[13] A total of 3,077 (1,217 men and 1,860 women; 1,062 monozygotic and 243 dizygotic twin individuals, 5 undetermined twin individuals, and 1,767 non-twin family members) individuals filled out the baseline questionnaire and provided weight and height measurements. Of the participants, 1,361 (482 men and 879 women; 558 monozygotic and 108 dizygotic twin individuals and 695 non-twin family members; age 44.6±12.5 years) individuals with follow-up data on eating behavior and weight (follow-up 2.7±0.9 years, range 1.1-5 years) were included in the analyses. Non-twin family members were more likely to be older (49.9±13.9 years vs 39.1±7.6 years) but had similar sex distribution (433 (62.3%) women vs 446 (67.0%) women) as compared with twins. Compared with the excluded subjects, the included subjects were more likely to have higher emotional eating score (1.43±0.66 vs 1.48±0.72, p=0.043). However, there were no significant differences in the scores of external and restrained eating, BMI, and age between the two groups.[9] This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Institutional Review Board of the participating institutions. Written informed consent was obtained from all subjects/patients.

Measures

Eating behavior was assessed by a validated Korean version of the Dutch Eating Behavior Questionnaire (DEBQ)[14] at baseline and follow-up. The questionnaire refers to three aspects of eating behavior: restrained eating (10 items), emotional eating (13 items), and external eating (10 items). A higher score reflects a greater tendency to exhibit that particular eating behavior. Its application method and reliability were described previously.[9] Weight and height were measured by trained research coordinators and assistants at baseline and follow-up. Body mass index was calculated by dividing the weight in kilograms by the height in meters squared. Information regarding education, alcohol consumption, pack-years of cigarette smoking, physical activity using the Korean version of the International Physical Activity Question-

Table 1. The characteristics of participants according to tertiles of restrained eating score at baseline (n=1361)

	Sex-specific tertiles of restrained eating at baseline, mean ± SD, n (%)			p for trend†
	Lowest tertile (n=460)	Middle tertile (n=458)	Highest tertile (n=443)	
Eating score at baseline				
Restrained	1.42 ± 0.29	2.30 ± 0.44	3.53 ± 0.64	<0.001
External	2.52 ± 0.83	2.69 ± 0.83	2.80 ± 0.78	<0.001
Emotional	1.28 ± 0.52	1.40 ± 0.58	1.61 ± 0.82	<0.001
Eating score change				
Restrained	0.41 ± 0.64	0.17 ± 0.69	-0.34 ± 0.86	<0.001
External	-0.05 ± 0.71	-0.04 ± 0.67	-0.16 ± 0.65	0.021
Emotional	0.05 ± 0.50	0.02 ± 0.50	-0.08 ± 0.63	0.001
BMI at baseline	22.7 ± 3.0	23.9 ± 3.2	24.5 ± 3.1	<0.001
Weight change	0.5 ± 3.0	0.2 ± 3.3	0.1 ± 3.6	0.070
Variables at baseline				
Age (y)	46.7 ± 13.5	43.6 ± 11.9	43.5 ± 11.9	<0.001
Women	305 (66.0)	296 (63.8)	286 (63.4)	0.410
Monozygotic twins	179 (38.9)	183 (40.0)	196 (44.2)	0.105
Dizygotic twins	28 (13.5)	34 (15.4)	46 (18.9)	0.177
≥ Graduate high school	162 (35.3)	214 (46.1)	223 (49.4)	<0.001
Income ≥ $3000/month	74			
Smoking (pack-years)	6.1 ± 15.1	5.0 ± 10.9	4.3 ± 10.4	0.030
Alcohol (g/week)	118 ± 272	110 ± 230	111 ± 179	0.722
Physical activity (MET)	7163 ± 11186	5625 ± 7956	6502 ± 11185	0.356
Energy intake (cal/day)	1932 ± 937	1879 ± 791	1831 ± 847	0.077
Known diabetes	21 (4.6)	28 (6.0)	13 (2.9)	0.237
Known hypertension	60 (13.0)	57 (12.3)	63 (14.1)	0.644
Known dyslipidemia	22 (4.8)	28 (6.0)	26 (5.8)	0.176
Known depression	15 (3.3)	11 (2.4)	16 (3.6)	0.792

Not all participants provided feedback on questions about income (n=1301).
†Trend analyses were conducted using linear by linear association for categorical variables and ANOVA (polynomial contrasts) for continuous variables.

naire,[15] daily energy intake using a validated 103-item semi-quantitative food frequency questionnaire,[16] and medical history of chronic diseases (hypertension, diabetes mellitus, dyslipidemia, and depression) were extracted from the baseline questionnaire.

Data analysis

Weight changes and the change in eating behavior scores were calculated by subtracting the values at baseline from the values at follow-up. The subjects were categorized into nine combined subgroups divided by sex-specific tertiles of restrained eating scores and tertiles of external (or emotional) eating scores at baseline. The characteristics of participants were compared according to sex-specific tertiles of restrained eating scores using ANOVA (polynominal contrasts) and chi-square tests. The relationships between weight change and score changes in the subscales were examined using Spearman rank correlation. To evaluate the associations of each of initial subscale score with initial BMI, weight change, and the change in each subscale scores, we conducted linear mixed models in which random effects (household and sibling effects) and fixed effects (sex, age, education level, smoking, alcohol use, energy intake, physical activity, medical history for diabetes mellitus, hypertension, dyslipidemia, and depression at baseline, and scores for other eating behavior subscales). Then, the associations between the combined subgroups and these outcomes were assessed using similar linear mixed models in which scores for other eating behavior were not considered for the fixed effects. These analyses were performed using PASW, Statistics 18 (Release 18.0.0 (July 30, 2009); SPSS Inc, Chicago, IL, USA).

RESULTS

Table 1 shows the characteristics of subjects according to sex-specific tertiles of restrained eating at baseline. The subjects who scored higher for restrained eating at baseline were more likely to score higher for external and emotional eating and have higher BMI at baseline. For the change in the scores according to increase in initial restrained eating tertiles, the scores for restrained and emotional eating were less likely to increase, while the scores for external eating were more likely to increase. However, there was no significant relationship between the change in weight and tertiles of restrained eating score at baseline. In overall subjects, BMI, weight, and the restrained eating score at follow-up were significantly higher than those values at baseline, while the external eating score decreased significantly and the emotional eating score was persistent over time (Table 2). The change in weight was weakly correlated with changes in restrained and external eating scores (spearman correlation coefficient 0.06; p=0.037, 0.10; p<0.001), while it was not correlated with change in emotional eating score (0.05; p=0.052).

In linear mixed analysis, initial scores for emotional and restrained eating were independently associated with higher initial BMI after adjusting for confounding factors including other eating scores, while these scores were not associated with weight changes over time. Initial eating behavior scores also had inverse associations with the change in corresponding eating behavior scores over time (Table 3). Tables 4 and 5 present the combined effects of initial emotional and restrained eating and initial external and restrained eating on concurrent BMI, weight changes over time, and the change in subscale scores over time. The initial BMI increased with increasing tertiles of restrained eating at baseline in each tertile of external/emotional eating at baseline after adjusting for confounding factors (p for trend <0.05). Weight changes over time decreased with increasing tertiles of restrained eating at baseline in the middle tertile of emotional eating (Table 4) and lowest tertile of external eating at baseline (Table 5, p for trend <0.05), while there were no significant linear trends in weight changes for other tertiles of external/emotional eating at baseline. There were decreasing trends in restrained eating over time for tertiles of restrained eating in each tertile of emotional (Table 4)/ external eating (Table 5, p for trend <0.05). Likewise, there were decreasing trends in emotional eating over time for tertiles of emotional eating in upper two tertiles of restrained eating (Table 4, p for trend <0.05). The inverse trends were also found in external eating over time for tertiles of emotional eating in all tertiles of restrained eating (Table 5, p for trend <0.05).

DISCUSSION

The focus of this prospective study in Korean twins and their family members was to examine the combined effect of external/emotional eating and restrained eating at baseline on concurrent BMI and the change in weight and eating behavior subscales over time. We found that BMI at baseline was positively associated with each eating behavior subscale at baseline and also increased with increasing restrained eating across external/emotional eating tertiles. In contrast, weight was more likely to decrease over time with increasing restrained eating tertile

Table 2. The comparison of BMI, weight, and eating behaviors at baseline and follow-up (n=1361)

	Baseline		Follow-up		p value[†]
	Mean	SD	Mean	SD	
Age (yr)	44.6	12.5	47.0	12.6	< 0.001
Body mass index (kg/m^2)	23.7	3.2	23.8	3.1	0.004
Weight (kg)	61.9	10.9	62.1	10.9	0.003
Scores of eating behaviors					
External eating	2.67	0.82	2.58	0.81	< 0.001
Emotional eating	1.43	0.67	1.43	0.69	0.967
Restrained eating	2.40	0.99	2.49	0.97	< 0.001

[†]Paired t-test

Table 3. The associations of baseline BMI, weight changes over time, change in eating behavior subscale score over time with baseline eating behavior subscale scores

		Baseline external eating	Baseline emotional eating	Baseline restrained eating
Baseline BMI (kg/m^2)	Age, sex-adjusted	0.19 (0.05, 0.32)	0.59 (0.42, 0.75)	0.77 (0.66, 0.89)
	Full-adjusted I*	0.34 (0.15, 0.52)	0.62 (0.40, 0.84)	0.74 (0.58, 0.89)
	Full-adjusted II†	0.07 (-0.22, 0.36)	0.45 (0.11, 0.79)	0.62 (0.39, 0.84)
Weight changes (kg)	Age, sex-adjusted	-0.20 (-0.42, 0.02)	0.04 (-0.23, 0.31)	-0.16 (-0.34, 0.03)
	Full-adjusted I*	-0.25 (-0.55, 0.06)	-0.15 (-0.50, 0.20)	-0.18 (-0.43, 0.07)
	Full-adjusted II†	-0.20 (-0.53, 0.13)	-0.02 (-0.41, 0.36)	-0.15 (-0.41, 0.11)
Change of external eating	Age, sex-adjusted	-0.42 (-0.46, -0.38)	-0.13 (-0.18, -0.07)	-0.07 (-0.11, -0.04)
	Full-adjusted I*	-0.37 (-0.43, -0.32)	-0.12 (-0.19, -0.05)	-0.06 (-0.11, -0.01)
	Full-adjusted II†	-0.36 (-0.42, -0.30)	0.06 (-0.01, 0.13)	-0.02 (-0.07, 0.03)
Change of emotional eating	Age, sex-adjusted	-0.13 (-0.18, -0.07)	-0.33 (-0.37, -0.29)	-0.06 (-0.09, -0.03)
	Full-adjusted I*	-0.05 (-0.10, -0.002)	-0.30 (-0.35, -0.25)	-0.03 (-0.07, 0.01)
	Full -adjusted II†	0.06 (0.01, 0.11)	-0.33 (-0.39, -0.27)	0.01 (-0.03, 0.05)
Change of restrained eating	Age, sex-adjusted	-0.07 (-0.11, -0.04)	-0.10 (-0.16, -0.03)	-0.37 (-0.41, -0.34)
	Full-adjusted I*	-0.09 (-0.16, -0.02)	-0.06 (-0.14, 0.02)	-0.36 (-0.41, -0.30)
	Full-adjusted II†	-0.04 (-0.11, 0.03)	0.06 (-0.03, 0.14)	-0.35 (-0.40, -0.29)

Assessed by linear mixed models*including random effects (household and sibling relation) and fixed effects (age, sex, education level, smoking, alcohol use, calorie intake, physical activity, and medical history such as diabetes mellitus, hypertension, dyslipidemia, and depression at baseline); †adjusted for the effects included in full-adjusted model I and other eating behavior scores at baseline.
Values are estimate (95% CI).

Table 4. Baseline BMI, weight changes over time, and change in restrained, external, and emotional eating scores over time among the subgroups divided by tertiles of initial restrained and emotional eating scores

	Lowest tertile of emotional eating			Middle tertile of emotional eating			Highest tertile of emotional eating		
	Lowest tertile of restrained eating	Middle tertile of restrained eating	Highest tertile of restrained eating	Lowest tertile of restrained eating	Middle tertile of restrained eating	Highest tertile of restrained eating	Lowest tertile of restrained eating	Middle tertile of restrained eating	Highest tertile of restrained eating
Initial BMI	23.9 ± 0.61	25.1 ± 0.63	25.7 ± 0.63*	24.7 ± 0.67	25.8 ± 0.65	25.9 ± 0.65*	24.3 ± 0.65	26.1 ± 0.62	26.3 ± 0.60*
Weight change	0.20 ± 0.70	-0.57 ± 0.72	-0.17 ± 0.71	1.08 ± 0.77	0.41 ± 0.73	-0.32 ± 0.75*	0.11 ± 0.74	-0.27 ± 0.70	-0.29 ± 0.68
Change in external eating	-0.06 ± 0.14	-0.06 ± 0.14	-0.03 ± 0.14	0.07 ± 0.16	-0.05 ± 0.15	-0.18 ± 0.15	-0.03 ± 0.15	-0.06 ± 0.14	-0.19 ± 0.14
Change in emotional eating	0.27 ± 0.11	0.30 ± 0.12	0.30 ± 0.12	0.26 ± 0.12	0.25 ± 0.12	0.26 ± 0.12	0.09 ± 0.12	0.11 ± 0.11†	-0.05 ± 0.11†
Change in restrained eating	0.43 ± 0.16	0.21 ± 0.16	-0.23 ± 0.16*	0.53 ± 0.17	0.34 ± 0.17	-0.16 ± 0.17*	0.56 ± 0.17	0.29 ± 0.16	-0.13 ± 0.15*

Numbers are estimated marginal mean ± SE
**p* for trend < 0.05 in subgroups of each tertile of emotional eating and † *p* for trend < 0.05 in subgroups of each tertile of restrained eating using linear mixed models including random effects (household and sibling relation) and fixed effects (age, sex, education level, smoking, alcohol use, calorie intake, physical activity, and medical history such as diabetes mellitus, hypertension, dyslipidemia, and depression at baseline).

Table 5. Baseline BMI, weight changes over time, and change in restrained, external, and emotional eating scores over time among the subgroups divided by tertiles of initial restrained and external eating scores

	Lowest tertile of external eating			Middle tertile of external eating			Highest tertile of external eating		
	Lowest tertile of restrained eating	Middle tertile of restrained eating	Highest tertile of restrained eating	Lowest tertile of restrained eating	Middle tertile of restrained eating	Highest tertile of restrained eating	Lowest tertile of restrained eating	Middle tertile of restrained eating	Highest tertile of restrained eating
Initial BMI	23.6 ± 0.64	25.4 ± 0.65	25.7 ± 0.65*	24.5 ± 0.63	25.8 ± 0.62	26.2 ± 0.62*	24.4 ± 0.64	25.6 ± 0.62	26.1 ± 0.59*
Weight change	1.23 ± 0.73	-0.14 ± 0.74	-0.59 ± 0.74*	-0.09 ± 0.72	-0.31 ± 0.71	-0.16 ± 0.71	-0.11 ± 0.73	-0.30 ± 0.70	-0.32 ± 0.68
Change in external eating	0.32 ± 0.14	0.29 ± 0.14	0.26 ± 0.14	0.02 ± 0.14	0.01 ± 0.13	-0.004 ± 0.13*	-0.26 ± 0.14†	-0.30 ± 0.13†	-0.35 ± 0.13†
Change in emotional eating	0.19 ± 0.12	0.20 ± 0.12	0.21 ± 0.12*	0.24 ± 0.12	0.18 ± 0.12	0.10 ± 0.12*	0.17 ± 0.12	0.24 ± 0.12	0.04 ± 0.11*
Change in restrained eating	0.59 ± 0.16	0.35 ± 0.17	-0.26 ± 0.16*	0.49 ± 0.16	0.25 ± 0.16	-0.07 ± 0.16*	0.41 ± 0.16	0.26 ± 0.16	-0.17 ± 0.15*

Numbers are estimated marginal mean ± SE

*p for trend < 0.05 in subgroups of each tertile of external eating and † p for trend < 0.05 in subgroups of each tertile of restrained eating using linear mixed models including random effects (household and sibling relation) and fixed effects (age, sex, education level, smoking, alcohol use, calorie intake, physical activity, and medical history such as diabetes mellitus, hypertension, dyslipidemia, and depression at baseline).

in the subjects with lowest external eating tertile and middle emotional eating tertile at baseline. The restrained eating score tends to attenuate over time with higher initial restrained eating status regardless of external/ emotional eating status at baseline. Likewise, the external and emotional eating scores were more likely to decrease over time when the corresponding eating behavior subscales at baseline were higher. These findings are worth noting, considering that there are no comparable researches on the combined effects of initial eating behavior subscales on weight changes and the change in eating behaviors over time.

The observed relationships between these subscales and weight over time may be explained with the interactions between dietary inhibition/disinhibition and weight, even though we cannot discern the exact path integrating these relationships. For instance, the subjects with higher external/emotional eating at baseline were more likely to overeat and have higher BMI at baseline; and then, increase restrained eating at baseline. If the subjects have higher restrained eating at baseline, they were more likely to suppress their external/emotional eating over time, particularly in those with higher levels of these eating subscales at baseline and then, suppress weight gain over time. As weight gain is smaller over time in those with higher restrained eating at baseline, restrained eating would result in a decrease over time. Alternatively, the subjects with higher BMI would more likely to lose their weight over time by higher restrained eating at baseline even though they have counteracting behaviors such as higher external/emotional eating. As the subjects lose their weight, they would less likely to restrain their eating over time and overeat by external/emotional stimuli. This assumption would be possible because any deleterious effects of restrained eating can be mediated by the disinhibition effect.[4, 5] Therefore, individuals who demonstrate higher self control of eating at baseline are less likely to self-regulate eating over time and those who have higher tendency to overeat by external or emotional stimuli at baseline result in decreases of these eating behaviors over time by interaction with baseline weight and weight changes over time. These observations confirmed natural psychological and physiologic compensation related to the regulation of food intake and explained the difficulties of long-term eating and weight control in community-based populations.

Although this study suggests meaningful findings, several limitations should be considered. The participants in our study may be more health conscious than the general population, thus, the characteristics of our subjects may not represent the characteristics of the general population. Therefore, the current findings may not be generalized to the populations with different social conventions for desirable weight status and in the context of clinical practice such as patients with eating disorder and patients on a diet. Other limitation of this study is that we were not able to examine the effects of unmeasured potential confounders such as self-esteem, weight concern, body image, and dieting behaviors.

In conclusion, from this prospective study in community-based populations, we demonstrated that the combination of restrained and external/emotional eating may be associated with concurrent BMI and predict changes in weight and the subscales over time. Therefore, Individuals with higher levels of restrained and external/emotional eating may be more likely to have higher concurrent BMI, lose their weight over time, and attenuate the levels of those subscales over time.

AUTHOR DISCLOSURES

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Yun-Mi Song, Kayoung Lee, and Joohon Sung, authors of this paper clearly declared that there were no conflict of interest for each of authors.

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Original Article

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前瞻性研究中飲食行為與體重變化：韓國健康孿生研究

本研究探討結合初始節制飲食與情緒性進食/外因性進食與初始身體質量指數(BMI)、隨時間之體重變化及這些飲食行為變化之間的關係。參與者為 1361 位韓國雙胞胎與家人(男性 482 位，女性 879 位)。在一段期間(2.7±0.9 年)內，測量兩次 BMI 和填寫荷蘭飲食行為問卷。受試者被分為結合性別差異初始節制飲食與外因性(或情緒性)飲食三分位的不同組合。在校正基線干擾因子(如：家戶、手足關係、性別、年齡、教育程度、吸菸、飲酒、能量攝取、體能活動與疾病史)後，執行線性混合模式。在校正後的模式，初始 BMI 隨初始節制飲食之分量上升而增加，在初始外因性或情緒性飲食之三個分位組皆然。在外因性飲食最低分位組與情緒性飲食的中分位組，體重的變化，不隨初始節制飲食的分量提高而增加。隨著相對應的飲食行為基線分量上升，該飲食行為之後續變化量降低。這些結果表示，高節制飲食和外因性/情緒性進食可能伴隨較高的 BMI、較少體重增加與降低相對應的飲食行為變化。

關鍵字：飲食行為、身體質量指數、體重變化、體重增加、肥胖