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Independent and combined relationship of habitual unhealthy eating behaviors with depressive symptoms: A prospective study



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ABSTRACT

Background: Unhealthy eating has been found to be associated with the prevalence of depressive symptoms. However, prospective evidence of the combined effects of unhealthy eating and depressive symptoms has not been reported. This study aimed to elucidate the prospective relationship between habitual unhealthy eating habits and depressive symptoms.

Methods: A 2-year prospective cohort study of 376 Japanese adults aged 24–83 years without depressive symptoms at baseline was conducted. Information about participants' eating behaviors was obtained via a self-administered questionnaire, in which skipping breakfast, eating dinner shortly before bedtime, and snacking after dinner were recorded. Depressive symptoms were assessed using the Japanese version of the Zung Self-rating Depression Scale.

Results: The 2-year incidence of depressive symptoms was found to be 23.7% (89/376). Covariate-adjusted multivariate Poisson regression analyses showed that habitual snacking after dinner was significantly associated with the incidence of depressive symptoms (relative risk [RR] 1.77; 95% confidence interval [CI], 1.00–3.14, $p = 0.049$), whereas no relationship was found between skipping breakfast or eating dinner shortly before bedtime and depressive symptoms. On the other hand, there was an interaction effect of snacking after dinner and dinner before bedtime on depressive symptoms (p for the interaction = 0.044). Participants with more than two unhealthy eating behaviors had a higher incidence of depressive symptoms compared to those with fewer than two unhealthy eating behaviors (RR 1.71; 95% CI, 1.06–2.77, $p = 0.028$).

Conclusions: This prospective study is the first to reveal the combined relationship between unhealthy eating and the incidence of depressive symptoms.

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1. Introduction

Depression is regarded as one of the most costly mental disorders,¹ and it has received attention because of its relationship to physical decline² and the risk of coronary heart disease and mortality.³ The prevalence of depressive symptoms has increased continuously during last two decades.^{4,5} Although population-based studies have found that poor health status, such as physical

limitations and cognitive decline, are potential risk factors for depressive conditions,⁶ it would seem to be more helpful to take preventive action against depressive symptoms before a person's health deteriorates. Accordingly, it is necessary to clarify the relationship between the lifestyle and behaviors that are characteristic of an ordinary life and the incidence of depressive symptoms.

Eating habits contribute to general health status. Population-based studies have found that some unhealthy eating habits, including skipping breakfast, snacking between meals, and eating at night, are associated with an elevated risk of diabetes.^{7,8} Among these, skipping breakfast has been associated with poor physical health⁹ and a decline in cognitive function.¹⁰ More importantly, an increasing number of studies have found that unhealthy eating habits are also likely to influence mental-health status. Older

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individuals who did not receive home-delivered breakfasts had a higher prevalence of depressive symptoms as compared to those who did receive them in one study.¹¹ Other epidemiologic studies have found that nighttime eating^{12,13} and habitual snacking¹⁴ are associated with depressive symptoms.

Although there is evidence of an association between unhealthy eating and depressive symptoms, a prospective relationship has not been established. Moreover, previous knowledge of the combined relationship of unhealthy eating habits with the prevalence of depressive symptoms has not been clarified. Thus, this population-based study aimed to investigate the prospective relationship between unhealthy eating behaviors (skipping breakfast, eating dinner shortly before bedtime, and snacking after dinner) and depressive symptoms, and to examine whether there is a combined impact of these eating habits on the incidence of depressive symptoms in adults.

2. Methods and materials

2.1. Study population

The Oroshisho Study is a prospective cohort study on risk factors of lifestyle-related diseases. In brief, the study was carried out between 2008 and 2011 at the Sendai Oroshisho Center, a group of over 120 small and medium enterprises in Sendai City, Japan. Participants received an annual health examination and answered questions about their mental health and daily lifestyle. Data collections were conducted when the subjects participated in an annual health examination, which was conducted in the second week of August every year. Data collected from 1263 participants in 2009 were used as baseline data for this study because detailed information about the participants' sleep status was available. Further details of the Oroshisho Study have been described elsewhere.¹⁵

In this study, 1215 adult employees agreed to provide written informed consent for their data to be analyzed (response rate: 96.2%). The participants without data on eating habits ($n = 46$) and depressive conditions ($n = 5$) were excluded. Participants with missing information on sleep disturbances, living status, and educational level were also excluded from the statistical analyses ($n = 6$). To evaluate the incidence of depressive symptoms over the 2-year follow-up period, an additional 606 adults were excluded because they had depressive symptoms at baseline, which were defined as a score of Zung Self-rating Depression Scale (SDS) more than 40.^{16,17} Finally, 176 participants were excluded because follow-up information on depressive conditions was unavailable; this left 376 individuals (300 men) aged 24–83 years old for the analysis. The protocol for the current study was approved by the institutional review board of the Tohoku University Graduate School of Medicine.

2.2. Eating behaviors

Unhealthy eating behaviors (skipping breakfast, eating dinner shortly before bedtime, and snacking after dinner) during the preceding month were measured using a self-administered questionnaire. The frequency of eating breakfast was assessed with the question: "How often do you eat breakfast that consists of a staple food?". The possible responses were 0–7 times/week. Participants who did not eat breakfast at least 3 times/week were considered to have skipped breakfast. Dinner before bedtime was assessed with the question: "Do you eat dinner within 2 h before bedtime more than three times a week?", which required a "yes" or "no" response. The following question was asked to assess snacking after dinner: "Do you eat snacks (not including three meals per day) after dinner

more than three times a week?", which required a "yes" or "no" response. Participants who responded affirmatively to these two dichotomous questions were categorized as those with the habits of eating dinner shortly before bedtime and snacking after dinner, respectively. Unhealthy eating behaviors (≥ 3 times/week) were defined based on a standard lifestyle questionnaire,¹⁸ which was developed by the Japan Ministry of Health, Labour and Welfare and is widely used for Specific Health Checkups (Tokutei Kenshin) in Japan.¹⁹

2.3. Depressive symptoms

Depressive symptoms were measured at baseline and follow-up with the SDS, which has been used with various types of patients and with healthy persons.¹⁶ The Japanese version of the SDS used in this study has been previously validated.²⁰ The 20 items of the scale are scored from 1 (little or none of the time) to 4 (most of the time) for each item, with a total SDS score ranging from 20 to 80; higher scores represent greater symptom severity. Participants scoring ≥ 40 on the SDS are regarded as having symptoms of mild depression.¹⁷

2.4. Relevant covariates

The frequency of daily intake of snacks/sweets during the preceding month was assessed using the Brief Dietary History Questionnaire (BDHQ), a self-administered tool.²¹ Based on the frequency of dietary consumption, the estimated daily intake of energy and fat were calculated using a computer program for the BDHQ, which was based primarily on the 5th edition of the Japanese Food Composition Table. Other lifestyle-related and socio-demographic information, including smoking status (current, former, or never), frequency of alcohol intake (every day, sometimes, or never), sex, age, occupation (desk work or not), marital status (married or not), living status (living alone or with others), and educational level (\geq college or not), were obtained using a self-administered questionnaire. Participants' duration of sleep per night was calculated based on the time they went to bed and the time they awoke. Sleep quality was assessed by the question: "Do you usually feel refreshed after sleep?", with the possible answers of "yes" or "no". Participants who responded negatively to this question were considered to have poor sleep quality. Sleep disturbance was classified according to the presence of one or more of the following factors during the previous month: use of sleeping pills because of trouble falling asleep, long time needed to fall asleep (more than 30 min), and restless movements of the limbs during sleep. Daily physical activity (PA) was measured using the International Physical Activity Questionnaire.²² Total PA was calculated and classified into three categories: 0, 0.1–22.9, and ≥ 23 metabolic equivalent (MET) hours/week. More than 23 MET hours/week is a recommended reference quantity for the prevention of lifestyle-related diseases in Japan.²³

Anthropometric parameters (height, body weight, and waist circumference) were measured according to a standardized protocol. Body mass index (BMI) was calculated as the ratio of weight to height² (kg/m^2) and was divided into three categories: < 21 , 21–24.9, and ≥ 25 kg/m^2 . Systolic and diastolic blood pressures were measured from the upper right arm using an automatic device (Yamasu 605P; Kenzmedico, Saitama, Japan) with the participant in the sitting position. Fasting blood samples were drawn from the antecubital veins of the participants who were in a seated position. Concentrations of serum glucose (Eurotec, Tokyo, Japan), triglycerides, and high-density lipoprotein-cholesterol (Sekisui Medical, Tokyo, Japan) were analyzed with enzymatic methods using the appropriate kits. Metabolic syndrome was defined according to

the criteria of the American Heart Association's Scientific Statement of 2009 for persons of Asian ethnicity.²⁴

2.5. Statistical analysis

Analyses were performed using IBM SPSS Statistics 22.0 software for Windows (IBM Corp, Armonk, NY, USA). Age, sleep duration, and daily intake of energy, fat, and snacks or sweets were log-transformed prior to the analysis to normalize the distribution of these skewed continuous variables. The term “combination of unhealthy eating behaviors” means that two or more of the factors (skipping breakfast, eating dinner shortly before bedtime, or snacking after dinner) were reported. The association of the sex-adjusted combination of unhealthy eating habits with participants' characteristics was tested using analysis of covariance or logistic regression model. Continuous variables are presented as means (standard deviations [SDs]) or geometric means (95% confidence intervals [CIs]) and categorical variables are presented as percentages.

Relative risks (RR) and 95% CIs for the association of depressive symptoms with combinations of unhealthy eating behaviors were calculated using Poisson regression analysis. The multivariate analysis included three main covariate-adjusted models, including sociodemographic and anthropometric, lifestyle-related, and health status-related confounding variables.⁹ Model 1 consisted of sex, age, BMI, occupation, marital status, living status, and educational level; Model 2 added daily intake of energy, fat, and snacks or sweets, smoking status, frequency of alcohol intake, PA, and sleep duration. Metabolic syndrome, sleep quality, and sleep disturbance were entered into Model 3 in addition to the variables in Model 2. Further, baseline SDS scores were also included in multivariate analysis to reduce the possibility of reverse causation (Model 4). The interactions between eating behaviors and confounding variables with the incidence of depressive symptoms were examined through the addition of the cross-product terms in the multivariate Poisson regression analysis. The same method was used to examine interaction effects among the three eating behaviors. All tests were two-sided, and a *p* value of less than 0.05 was considered statistically significant.

3. Results

3.1. Participant characteristics

The sex-adjusted participant characteristics are presented in Table 1 according to the number of unhealthy eating behaviors. The mean (SD) age of this population of 376 adult employees was 46.9 (11.0), of which 20.2% (76/376) were women. More than one-fourth of the adults reported two or more unhealthy eating habits. Participants with two or more of the unhealthy eating behaviors were younger than those who reported one or none of them (*p* = 0.021). BMI, daily snack or sweet intake, and the proportion of participants with poor sleep quality were significantly higher in subjects with plural unhealthy eating habits (*p* < 0.05). Participants who had plural unhealthy eating habits tended to have a smoking habit, lower PA, short sleep duration, and sleep disturbances, although a significant association was not found. Other variables did not differ between the groups.

3.2. Eating behaviors and depressive symptoms

At baseline, breakfast skipping was shown to be associated with higher prevalence of depressive symptoms (*p* = 0.026) (eTable 1). The incidence of depressive symptoms over the 2-year period was 23.7% in this population of adult Japanese employees. The

prospective relationship between each of the eating behaviors and the incidence of depressive symptoms are presented in Fig. 1. A prospective relationship between snacking after dinner and the incidence of depressive symptoms after adjusting for the covariates was observed (RR 1.77; 95% CI, 1.00–3.14). Skipping breakfast and eating dinner shortly before bedtime did not have a significant correlation with the incidence of depressive symptoms. Moreover, the significant association between habit of snacking after dinner and depressive symptoms was limited to those who had habit of having dinner shortly before bedtime (*p* for the interaction = 0.044, Table 2).

3.3. Combined association of eating behaviors with depressive symptoms

The relationships of the combined eating behaviors with depressive symptoms are presented in Table 3. Univariate analysis showed that, compared to participants who had one or none of the unhealthy eating behaviors, those with two or more of them had a significantly higher incidence of depressive symptoms (RR 1.80; 95% CI, 1.16–2.79). After controlling for baseline SDS scores and sociodemographic, anthropometric, lifestyle-related, and health status-related covariates, this association remained significant (RR 1.71; 95% CI, 1.06–2.77). Similarly, the incidence of depressive symptoms was higher across the number of unhealthy eating habits in the fully adjusted model, although the difference was not significant (*p* for the trend = 0.084). The multivariate Poisson regression analysis showed an interaction between the combined eating behaviors and deskwork, fat intake, and snack/sweet intake with depressive symptoms (*p* for the interaction < 0.05, results not shown).

4. Discussion

The current study found that snacking after dinner was related to a higher incidence of depressive symptoms during the 2-year follow-up period. Furthermore, this prospective study of Japanese adults is the first to indicate a combined association of breakfast skipping, eating dinner shortly before bedtime, and snacking after dinner with the incidence of depressive symptoms, after controlling for baseline depressive state and sociodemographic, anthropometric, lifestyle-related, and health status-related confounding variables.

The participants included in this study were at high risk for depressive symptoms, as a 52.2% prevalence rate of depressive symptoms in the adult employees was found at baseline. These results are in agreement with the report by Kawakami et al., in which a 44.7% prevalence of depressive symptoms among Japanese male employees was observed.²⁵ Similarly, further evidence showed that the mean score of the SDS in Japanese workers was approximately 40 points,²⁶ which is the cutoff value for depressive symptoms.¹⁷ Results of these studies indicate a high prevalence of depressive symptoms among Japanese employees.

The association between unhealthy eating behaviors and depressive disorders has been noted in some cross-sectional studies. The habit of skipping breakfast^{11,27,28} has been found to be associated with a higher prevalence of depressive symptoms, which is consistent with the baseline results from our study. In addition, a previous study indicated that eating dinner shortly before bedtime was associated with depressive symptoms in a population of Japanese adults.²⁸ In our study, similarly, subjects with habitual behaviors of having dinner shortly before bedtime tended to have a higher prevalence (and incidence) of depressive symptoms, although the association was not statistically significant. Further, the finding of a prospective relationship between

Table 1

Sex-adjusted baseline participants' characteristics according to the combination of unhealthy eating behaviors.

Variables	Number of unhealthy eating behaviors		p value ^a
	0–1	2–3	
Participants, n	293	83	
Female sex, %	21.8	14.5	0.139
Age, years ^b	46.3 (45.1–47.6)	43.3 (41.2–45.6)	0.021
BMI, kg/m ²	23.2 (22.8–23.6)	24.1 (23.4–24.9)	0.021
Education (\geq college), %	29.7	41.0	0.112
Occupation (desk work), %	80.9	83.1	0.489
Marital status (married), %	74.4	72.3	0.435
Living status (alone), %	9.6	15.7	0.104
Smoking status			
Current, %	35.2	48.2	
Former, %	14.3	12.0	
Never, %	50.5	39.8	0.090
Alcohol intake frequency			
Every day, %	27.6	26.5	
Sometimes, %	52.6	56.6	
Never, %	19.8	16.9	0.838
PA, MET hours/week			
0, %	20.5	27.7	
0.1–22.9, %	39.2	38.6	
\geq 23, %	40.3	33.7	0.101
Energy intake, kcal/day ^b	1776 (1713–1841)	1772 (1656–1896)	0.957
Fat intake, g/day ^b	47.8 (45.7–50.1)	48.2 (44.2–52.6)	0.871
Snack/sweet intake, g/day ^b	35.3 (31.8–39.1)	49.7 (41.3–59.4)	0.002
Sleep duration, minutes ^b	402 (395–409)	391 (379–403)	0.112
Sleep quality (poor), %	24.9	34.9	0.036
Sleep disturbance, %	17.1	26.5	0.057
Metabolic syndrome, %	23.2	25.3	0.761
Skipping breakfast, %	20.5	86.7	<0.001
Eating dinner before bedtime, %	30.7	85.5	<0.001
Snacking after dinner, %	7.5	42.2	<0.001

BMI, body mass index; MET, metabolic equivalent; PA, physical activity.

Data are presented as mean (95% confidence interval), unless otherwise indicated.

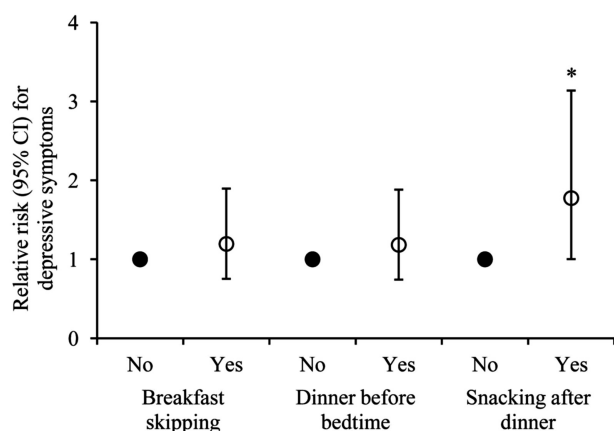
^a Differences were evaluated using analysis of covariance and logistic regression, as appropriate.^b Variables were log-transformed due to a skewed distribution.

Fig. 1. The prospective relationship between eating behaviors and the incidence of depressive symptoms. The multivariate analysis used Poisson regression. Data are presented as relative risk and 95% confidence intervals (CI). Covariates, including sex; log age; body mass index (<21, 21–24.9, \geq 25); occupation (desk work); marital status (married); living status (alone); educational level (\geq college); log daily energy, fat, and snack or sweet intake; smoking status (current, former, never); frequency of alcohol intake (every day, sometimes, never); physical activity (0, 0.1–22.9, \geq 23 metabolic equivalent hours/week); log sleep duration; metabolic syndrome; sleep quality (poor); sleep disturbance; and Self-rating Depression Scale (scores) at baseline. The analysis included 376 participants. * $p < 0.05$ compared to the reference.

evening snacking and depressive symptoms in this study was also partially supported by several cross-sectional or clinical studies, in which evening snacking was correlated with depressive disorders.^{8,12,29} The finding of a higher incidence of depressive

symptoms with a higher number of unhealthy eating behaviors in this prospective study provides additional evidence on the potential contribution of eating habits to mental health. In contrast to previous studies, in which the focus of research has been on the impact of depressive symptoms on eating habits,³⁰ we considered depressive symptoms to be a consequence of these unhealthy behaviors. Taken together, these findings reveal the possibility of a vicious circle between unhealthy eating habits and mental health problems.

Overall, unhealthy eating habits may negatively affect mental status through several potential pathways. In this study, the association between unhealthy eating behaviors and depressive symptoms was moderated by a significant interaction effect of desk work, fat intake, and snack/sweet intake. Deskwork is considered a sedentary type of occupation³¹ that leads to depressive symptoms.³² These observations suggest that desk workers with long periods of sitting and unhealthy eating habits may be at high risk for mental disorders. Additionally, this study indicates that these unhealthy habits, especially snacking after dinner, are combined with a greater consumption of snacks and fat, which have been reported to be associated with depressive disorders.^{14,33} Therefore, unhealthy eating habits may be related to an elevated risk of depressive symptoms, which is partially dependent on the excessive intake of fat-enriched food, such as snacks or sweets. In our study, participants with only one unhealthy eating behavior had a relatively lower risk of depressive symptoms than subjects with multiple unhealthy eating behaviors. This may have resulted from a high proportion of subjects with the habit of having dinner shortly before bedtime, which was associated with low intakes of snacks/sweets (mean [SD]: 3.79 [0.72] vs. 3.94 [0.69], $p = 0.034$). In fact,

Table 2
Interaction effect of unhealthy eating behaviors on depressive symptoms.

	Breakfast skipping	Dinner before bedtime	Snacking after dinner
Breakfast skipping			
<i>p</i> value for the interaction ^a		0.947	0.247
Dinner before bedtime			
<i>p</i> value for the interaction			0.044

^a Adjusted for sex, log age, body mass index (<21, 21–24.9, ≥25), occupation (desk work), marital status (married), living status (alone), education level (≥college), log daily energy, fat, and snack or sweet intakes, smoking status (current, former, never), alcohol intake frequency (every day, sometimes, never), physical activity (0, 0.1–22.9, ≥23 metabolic equivalent hours/week), log sleep duration, metabolic syndrome, sleep quality (poor), sleep disturbance, and Self-rating Depression Scale (scores) at baseline.

Table 3
Multivariate Poisson regression of the relative risk of incident depressive symptoms by combinations of unhealthy eating behaviors at follow-up.

	Relative risk (95% confidence interval)				
	Non-adjusted	Model 1 ^a	Model 2 ^b	Model 3 ^c	Model 4 ^d
Number of unhealthy eating behaviors					
0–1 (n = 293)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
2–3 (n = 83)	1.80 (1.16–2.79)	1.88 (1.20–2.96)	1.86 (1.16–2.97)	1.83 (1.14–2.95)	1.71 (1.06–2.77)
<i>p</i> value	0.009	0.006	0.010	0.012	0.028
Number of unhealthy eating behaviors					
0 (n = 121)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1 (n = 172)	0.89 (0.53–1.49)	0.88 (0.53–1.48)	0.85 (0.50–1.43)	0.83 (0.49–1.41)	0.84 (0.49–1.41)
2 (n = 71)	1.57 (0.90–2.74)	1.62 (0.91–2.88)	1.57 (0.87–2.85)	1.53 (0.84–2.78)	1.39 (0.76–2.54)
3 (n = 12)	2.33 (0.96–5.65)	2.45 (1.00–6.01)	2.27 (0.90–5.73)	2.26 (0.89–5.77)	2.41 (0.94–6.15)
<i>p</i> value for trend	0.032	0.025	0.046	0.057	0.084

^a Adjusted for sex, log age, body mass index (<21, 21–24.9, ≥25), occupation (desk work), marital status (married), living status (alone), and education level (≥college).

^b Same as Model 1 + log daily energy, fat, and snack or sweet intakes, smoking status (current, former, never), alcohol intake frequency (every day, sometimes, never), physical activity (0, 0.1–22.9, ≥23 metabolic equivalent hours/week), and log sleep duration.

^c Same as Model 2 + metabolic syndrome, sleep quality (poor), and sleep disturbance.

^d Same as Model 3 + Self-rating Depression Scale (scores) at baseline.

previous studies have demonstrated that consumption of snacks/sweets is a risk factor for depressive symptoms^{34,35} In addition, there is a possibility that, compared with those with only one unhealthy eating behavior, participants without unhealthy eating behaviors in this study may have had some other unhealthy eating behaviors (not assessed in our study) that may have contributed to depressive symptoms, such as binge eating³⁶ and emotional eating.³⁷

It is worth noting that a significant association of snacking after dinner with depressive symptoms was only found in participants with a habit of having dinner shortly before bedtime, suggesting an additional impact of night eating habits in the association between evening snacking and depressive symptoms. The potential mediating role of night eating-induced changes in hormone secretions may explain these findings. Allison et al. found that circulating ghrelin levels decreased significantly in participants with night eating habits.³⁸ Ghrelin, a hormone that has been recognized as an appetite-stimulating peptide, might be involved in the prevention or mitigation of depressive symptoms in animals and humans.^{39–41} Moreover, both skipping breakfast and eating at night have been characterized as circadian delays in daily food intake that could lead to disrupted sleep.^{42,43} Participants with such circadian and sleep disturbances are more prone to mood disorders.^{44,45} Considering that the sleep status assessed in this study did not represent all the symptoms of sleep disturbances, further evidence of the possible mediating role of sleep disturbances in the association between unhealthy eating habits and depressive symptoms is needed.

Some limitations of the study need to be mentioned. It is not clear whether there is an association between eating behaviors and moderate or severe depressive symptoms because the degree of depressive symptoms could not be assessed due to the relatively small sample size. In addition, this study did not evaluate other important eating habits, including binge eating and emotional

eating, which might be related to depressive symptoms.^{36,37} Further, there is a possibility of drop-out bias resulting from loss to follow-up due to a relatively high attrition rate (31.9%) in this study.

In conclusion, this prospective study revealed a combined impact of skipping breakfast, eating dinner shortly before bedtime, and snacking after dinner on depressive symptoms in Japanese adults. These findings emphasize the importance of the possible protective role that improvements in eating habits might have on depressive disorders. Further intervention studies are warranted to examine the effect of modification of eating habits on depressive symptoms.

Conflicts of interest

None declared.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.je.2016.08.005>.

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