

# Physical activity and the prevalence of primary headaches among a large population of university students: The MEPHASOUS study

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## Research article

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## **Abstract**

Background: Primary headaches have a high prevalence among university students. Lifestyle has an important role in the prevention and management of these headaches. Among lifestyle factors, data on the association between physical activity and primary headaches are scarce and conflicting.

Aim: To examine the association between physical activity and primary headaches among a large population of university students.

Methods: Totally, 83,463 university students from 28 provinces of Iran were included in the current cross-sectional study. Data on physical activity, dietary intakes, and demographic characteristics were collected using pre-tested questionnaires. Primary headaches were determined according to the International Classification of Headache Disorders-3 (ICHD-3) criteria.

Results: Mean age of university students was  $21.50 \pm 4.01$ , and 54.7% were female. Primary headaches were prevalent among 9% of students. A significant inverse association was seen between physical activity and primary headaches in the whole population (OR: 0.66, 95% CI: 0.62-0.71). Such an inverse association was also observed after taking potential confounders into account; such that students who were physically active had 21% lower odds of primary headaches compared with those who were physically inactive (OR: 0.79, 95% CI: 0.72-0.87). Also, physical activity was associated with reduced odds of primary headaches in male and female students (Males; OR: 0.70, 95% CI: 0.60-0.82, females; OR: 0.84, 95% CI: 0.75-0.94) as well as those students with normal-weight (OR: 0.79, 95% CI: 0.71-0.87), overweight, or obesity (OR: 0.80, 95% CI: 0.66-0.96).

Conclusion: Our findings support the protective association between physical activity and primary headaches.

## **Introduction**

Primary headaches including migraine, tension-type, and non-classifiable headaches have been considered as the top contributor to disability in people under 50 years old [1, 2]. The high prevalence of primary headaches is a major concern for health care systems. The prevalence of migraine headaches is from 10–18% worldwide [3]. However, this prevalence is higher among youth such as university students; such that 11.3% of male students and 21.7% of female students are affected [3]. Therefore, detecting the contributing factors to the incidence of primary headaches would help us to prevent and manage these headaches.

Lifestyle-related factors have a major role in the prevention of primary headaches [2, 4, 5]. Adherence to a healthy diet and having a stress-free life with a regular sleep pattern have a protective effect against primary headaches [5–10]. Another lifestyle-related factor is physical activity which its association with primary headaches is not so clear yet. It is assumed that physical activity increases the secretion of encephalins and endorphins in the nervous system [11]. These neurotransmitters provide an analgesic effect within and after exercise [11]. In addition, physical activity has been shown to beneficially affect chronic pain conditions comorbid with migraine including anxiety and depression [12]. However, some patients with primary headaches believe that physical activity is a triggering factor for their headaches [13, 14]. This a reason for low physical activity among these patients.

Besides, available evidence presents conflicting data on the association between physical activity and primary headaches. In a study on 22,397 adults, Varkey et al. reported that a sedentary lifestyle is a risk factor for non-migraine headaches [15]. In a case-control study, patients with headache were more likely to be physically inactive compared with healthy controls [16]. In contrast, Farris et al. showed that frequent physical activity increased the incidence of migraine headaches and also enhance the severity of pain [17]. Overall, despite the limited evidence, the association between physical activity and primary headaches has long been a question for researchers. In addition, most studies on the association between physical activity and primary headaches are from western nations and no study examined this association in the Middle East. People in this region usually have low physical activity and also the prevalence of primary headaches is estimated to be high among the Middle Eastern population [18, 19]. In addition, previous studies on the relation between physical activity and primary headaches have mainly conducted on adults and little attention has been paid on youth such as university students who have different lifestyle compared with others and the prevalence of primary headaches among them is estimated to be high [3, 20]. Hence, the current study aimed to assess the association between physical activity and primary headaches among a large population of Iranian university students.

## Material And Methods

**Participants:** This cross-sectional study was a part of the mental and physical health assessment of university student (MEPHASOUS) project which was performed in 2012-2013. This project was aimed to determine the contributing factors to the health problems and unhealthy behaviors of Iranian university students. Details on the study design, sampling methods, and data gathering in the MEPHASOUS project have been published previously [21,22]. In the MEPHASOUS project, all students from 74 governmental universities (in the provinces of Iran), related to the Ministry of Science and Technology (MST), were asked to take part in the study. Inclusion criteria were the registration in a governmental university and being in an age range of  $\geq 18$  years. The data collection was conducted in the health centers of universities. All required data on demographic variables, physical activity, anthropometric measures, medical history, and dietary intakes were gathered from each student via pre-tested questionnaires. After merging the data and removing the students with missing information, 83,463 students remained for the final analysis. All participants signed the informed consent document. The ethics committee of the Ministry of Science and Technology, Tehran, Iran approved the whole project.

**Physical activity assessment:** Because of the high sample size of the MEPHASOUS study, we used a short question for the assessment of physical activity. Participants were asked how many times per week they do exercise with a moderate-to-high severity for 30 minutes. The response option for this question was: "rarely", "1-2 times/wk", "3-4 times/wk", ">5 times/wk". We considered students who had physical activity  $\geq 3$  times/wk as physically active and those with a rare physical activity as inactive. Also, having physical activity 1-2 times/wk was considered a moderate physical activity.

**Assessment of primary headaches:** Primary headaches were evaluated using a self-reported question by which students were asked whether they had experienced primary headaches (including migraine, tension-type headache, and non-classifiable headache) during the last 12 months. They were asked to not report the headaches related to cold, fever or any other type of illness. Students could select two options (yes/no). If yes, they were referred to a general practitioner, who was experienced in terms of neurovascular diseases, for further

examination. Primary headaches were defined according to the criteria introduced by the International Classification of Headache Disorders-3 (ICHD-3) with the exceptions that the number of attacks and the duration of headaches were not included [23].

**Dietary habits:** In order to collect information on dietary intake of selected food groups and also breakfast consumption patterns, a self-administered validated dietary habits questionnaire was used. A previously published article revealed the reliability and validity of the questionnaire [21]. Students were asked to report their dietary intakes for fresh and dried fruits, vegetables, dairy products, fast foods, sugar-sweetened beverages (SSBs), and sweets during the last year. In the questionnaire, the response categories were different for each food item based on its usual intake among the Iranian population. For example, the response categories for fruits which are frequently consumed by Iranians were in daily format (<1 serv/day, 1 serv/day, 2-3 serv/day, ≥4 serv/day), while these categories for sweets which are infrequently consumed were in weekly format (<1 serv/wk, 1 serv/wk, 2-3 serv/wk, ≥4 serv/wk). In addition to dietary intakes, students were asked to report the frequency of breakfast consumption in a week by the use of these options: <1 day/wk, 1-2 days/wk, 3-4 days/wk, ≥5 days/wk. Breakfast skipper was defined as individuals who consumed breakfast ≤4 days/wk.

The reliability of the dietary habits questionnaire was examined in a separate study which was done on a subgroup of 70 students in each center of the MEPHASOUS project (total: 1960 students) [21]. In that study, a test-retest reliability process was applied in order to estimate the reliability of the questionnaire. Participants were asked to fill the dietary habits questionnaire two times with a 2–3 weeks' interval. The correlation coefficients for all dietary habits between the two times were more than 0.60 indicating sufficient reliability of this questionnaire. The reliability and validity of the questionnaire were also confirmed by previous studies which applied this questionnaire for the assessment of dietary habits [22,24,25].

**Assessment of other variables:** We used a self-reported pre-tested questionnaire to gather data on age, gender (male/female), education (advanced diploma/bachelor of science (BSc)/master of science (MSc)/medical science (MD)/philosophy of doctor (Ph.D.)), marital status (single/married), occupation (having/not-having), health insurance (having/not-having), smoking (non-smoker/ex-smoker or current smoker), and current use of nutritional supplements (including Fe, Ca, vitamins and other nutritional supplements) (yes/no). Students who were in the advanced diploma, BSc and MD courses were defined as the under-graduate students and those students in the MSc and Ph.D. courses were considered as the graduate students. Since health insurance in Iran can cost a lot for people, it was considered as an index for the evaluation of economic status. Therefore, we considered students who had health insurance as economically "good" and those who did not have any type of health insurance as economically "weak". In addition, sleep pattern was assessed by the two questions: "how is your pattern of sleeping and awaking?" and "how many hours do you sleep in a day?" The response options for the first question were "regular", "irregular" and for the second question were: "<6 hours/day", "6-8 hours/day", "8-10 hours/day", ">10 hours/day. Due to the probable influence of internet addiction on physical activity and maybe primary headaches, we assessed the time that each student spend for the use of internet-connected devices including computer, cell phone, and notebook in a day. They should answer the question by these choices: "rarely", "<2 hours/day", "2-4 hours/day", and ">4 hours/day". Using of these devices >4 hours/day were considered as frequent use. In order to measure anthropometric indices, we employed a standard procedure to measure weight and height. We calculated the body mass index (BMI) as weight (kg)/height (in square meters). Overweight and obesity were considered as the BMI of 25-30 and ≥30 kg/m<sup>2</sup>, respectively [26,27]. Blood

pressure was measured in a seated position after a 5-min rest two times with a 20-minute interval. The average of two measurements was considered as the final systolic and diastolic blood pressure. Hypertension was defined as systolic blood pressure (SBP)  $\geq 140$  mmHg and diastolic blood pressure (DBP)  $\geq 90$  mmHg [28].

**Statistical analysis:** We first classified students according to three categories of physical activity (inactive, moderate, and active). One-way analysis of variance (ANOVA) was employed to assess differences in continuous variables among the levels of physical activity. To evaluate the distribution of categorical variables across the categories of physical activity, the Chi-square test was used. Binary logistic regression in multivariable-adjusted models was used to obtain odds ratios (ORs) of primary headaches across the levels of physical activity. This analysis was performed among the whole population and separately by gender and BMI status ( $<25/\geq 25$  kg/m<sup>2</sup>). For creating the adjusted models, we first included age and gender (not included in the sex-stratified analysis) into the model (first model). Then, we included other variables including marital status, education, occupation, economic status, smoking, the use of internet-connected devices, sleep pattern, hypertension, supplement use, and breakfast skipping in the second model in addition to variables belong to model 1. Further adjustment was made for the consumption of fruits, vegetables, dairy products, fast foods, SSBs, and sweets in model 3. In the last model, we additionally controlled for BMI to obtain an obesity-independent association between physical activity and primary headaches. In this analysis, the reference group was considered those students who were physically inactive. Also, to compute the P-value for the trend of odds ratios across the levels of physical activity, we considered these levels as an ordinal variable in binary logistic regression. All statistical analyses were done using SPSS software (version 19.0; SPSS Inc, Chicago IL). P values were considered significant at  $<0.05$ .

## Results

The mean age of university student participated in the current study was  $21.50 \pm 4.01$ . Also, 54.7% of study participants were female. Primary headaches were prevalent among 9% of participants. Moreover, 39.9% of students were physically active and 16.1% were physically inactive.

Demographic characteristics and dietary habits of students across different levels of physical activity are shown in **Table 1**. Compared with those students who were physically inactive, active students were more likely to be male, use nutritional supplements, have a regular sleep pattern and good economic status, and less likely to be married, graduate, breakfast skipper, current smoker, have a job, use net-connected devices, and have hypertension and primary headaches. Also, age and BMI values, as well as the prevalence of overweight and obesity, were significantly different across the categories of physical activity. In terms of dietary intakes, active students had higher intakes of fruits, vegetables, dairy products, and lower intakes of fast foods, SSBs, and sweets compared with physically inactive students.

Multivariable-adjusted ORs and 95% CIs for primary headaches across the categories of physical activity are presented in **Table 2**. A significant inverse association was seen between physical activity and primary headaches in the whole population (OR: 0.66, 95% CI: 0.62-0.71). Such an inverse association was also observed after taking potential confounders including demographic and socio-economic variables as well as dietary intakes of selected food groups into account (OR: 0.80, 95% CI: 0.73-0.87). Further adjustment for BMI did not change the significant inverse association; such that students who were physically active had 21% lower odds of primary headaches compared with those who were physically inactive (OR: 0.79, 95% CI: 0.72-0.87).

Multivariable-adjusted ORs and 95% CIs for primary headaches across the categories of physical activity stratified based on gender and BMI status are indicated in **Table 3**. There was a significant inverse association between physical activity and primary headaches in male and female students. This association remained significant even after controlling for potential confounders; such that higher physical activity in male and female students was associated with 30% and 16% lower odds of primary headaches, respectively (Males; OR: 0.70, 95% CI: 0.60-0.82, females; OR: 0.84, 95% CI: 0.75-0.94). The same findings were also observed in the stratified analysis based on BMI status. In normal-weight students, those who were physically active were 21% less likely to have primary headaches compared with inactive students (OR: 0.79, 95% CI: 0.71-0.87). Also, in students with overweight or obesity, frequent physical activity was associated with 20% lower odds of primary headaches (OR: 0.80, 95% CI: 0.66-0.96).

## Discussion

In the present study, we found that physical activity had a protective association with primary headaches. This association was also seen after controlling for potential covariates. In subgroup analyses, a significant inverse association was found between physical activity and primary headaches in male and female students as well as students with normal-weight, overweight, or obesity. To the best of our knowledge, the current study is the first to examine the association between physical activity and primary headaches among university students in the Middle East.

Primary headaches are debilitating, progressive and chronic neurovascular disorders that are characterized by severe and long-lasting headaches and may be associated with nausea, vomiting, photophobia, phonophobia, neck pain, and muscle tension [29, 30]. Lifestyle-related factors including diet and sleep pattern are involved in the etiology of primary headaches [2, 31, 32]. Another factor is physical activity. However, there is no clear association between physical activity and primary headaches. In the current study, we found that physical activity was associated with reduced odds of primary headaches. In agreement with our findings, a review article revealed that aerobic exercise can alleviate the duration of migraine headaches and also somewhat decrease the incidence of these headaches [33]. In another similar study, a beneficial effect of exercise on primary headaches including migraine and tension-type headaches and also a decrease in the use of headache-related medications were reported [34]. In a study on 22,397 adults, a sedentary lifestyle was associated with an increased risk of non-migraine headaches [15]. In a population-based study in Canada, some forms of physical activity were inversely associated with odds of migraine in women: walking for 30 minutes but less than 1 hour, light sports for less than 30 minutes, strenuous sports for 30 minutes but less than 1 hour [35]. Overall, it seems that regular physical activity has a protective association with the incidence of primary headaches.

Physical activity increases the secretion of beta-endorphin, as an endogenous opioid, which is produced by the anterior pituitary and endorphins in the nervous system [36–38]. Beta-endorphin leads to analgesia by binding to pre- and post-synaptic opioid receptors [39]. Moreover, beta-endorphin decreases the secretion of substance P which is involved in the transmission of pain pathways in the peripheral nervous system [40]. In the central nervous system, the decrease in substance P results in presynaptic inhibition of gamma-aminobutyric acid (GABA) [14]. This inhibition increases the production of dopamine which is associated with pleasure [41]. In addition, physical activity increases the release of cannabinoids 1 (CB1) and 2 (CB2) which through their receptors can mediate pain reduction [42]. It has been shown that the concentrations of cannabinoids in

migraine patients are less than healthy individuals [43]. Physical activity may have a benefit for the prevention of primary headaches through an increase in nitric oxide (NO) levels [44, 45]. Given that endothelial dysfunction is involved in primary headaches, NO may protect the endothelium by reducing norepinephrine, and preventing the production of vasoconstrictors and free radicals in vessel walls [44, 46].

Although our study and some other studies have shown that physical activity is associated with reduced odds of primary headaches, the recommendation of physical activity to patients with these headaches should be with caution. Amin et al. reported that exercise can trigger migraine attacks; however, regular exercise may have a prophylactic effect on the frequency of migraine attacks [14]. In patients with primary headaches, physical activity may increase or decrease the triggering threshold of primary headaches. There is large variability in the effect of physical activity on the incidence of primary headaches that can be accounted for by individual differences [17]. In a study on 132 women with migraine, physical activity worsened headache severity in 34.8% of migraine attacks, had no effect on 61.8% of the attacks and improved headache severity in 3.4% of the attacks [17]. Overall, migraine patients should be encouraged to do exercise with a certain intensity, frequency and duration to reach the most beneficial outcome while managing potential injuries and side effects [47]. However, further studies are needed to determine the appropriate type and duration of physical activity for patients with primary headaches.

Several strengths of the current study need to be highlighted. This study was the first that recruited a large sample size of university students in the Middle East to investigate the relation between physical activity and primary headaches. Furthermore, a wide range of potential confounders was taken into account to obtain an independent association between physical activity and primary headaches. In addition to the whole population, we performed stratified analyses based on gender and BMI status. Employing university students might increase the accuracy of the collected data. Given these strengths, some limitations must be considered when interpreting our findings. Because of the cross-sectional design of our study, establishing a causal link between physical activity and primary headaches is impossible. Further studies, in particular of prospective design, are required to confirm our findings. In the current study, we focused on primary headaches generally, whereas the association of physical activity with specific types of primary headaches might be different. Although several confounders were taken into account to reach an independent association, further control for other variables such as psychological disorders and residual lifestyle factors might be needed. In addition, the study was conducted on a population of university students, and extrapolating our findings to the general population must be done cautiously. Although we applied validated questionnaires, the misclassification of study participants in terms of physical activity cannot be excluded. In the current study, we could not assess the types of physical activity (aerobic, muscle-strengthening, bone-strengthening, and stretching). However, the associations between each type of physical activity and primary headaches might be different.

## Conclusions

Physical activity was associated with reduced odds of primary headaches in university students. Such an inverse association was also seen in male and female students as well as those with normal-weight, overweight, and obesity. Further studies are needed to confirm our findings.

## Abbreviations

ICHD-3: International Classification of Headache Disorders-3, MEPHASOUS: Mental and Physical Health Assessment of University Student, MST: Ministry of Science and Technology, BMI: Body Mass Index, DBP: Diastolic Blood Pressure, SBP: Systolic Blood Pressure

## Declarations

**Ethics approval and consent to participate:** All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All participants provided a signed written consent form.

**Consent for publication:** Not applicable

**Availability of data and materials:** The dataset that was analyzed in the current study is available from the corresponding author on reasonable request.

**Competing interests:** The authors declare that they have no competing interests.

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**Authors' contributions:** MM, FS, MV, and AK contributed to study conception, design, and data collection. OS contributed to statistical analysis. OS, HR and AS contributed to manuscript drafting. All authors acknowledge the full responsibility for the analyses and interpretation of the report. All authors read and approved the final manuscript.

**Conflict of interest:** The authors have no conflicts of interest to declare.

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# Tables

1: Demographic characteristics and dietary habits of participants across the categories of physical activity

Variables	Inactive <sup>1</sup>	Moderate <sup>2</sup>	Active <sup>3</sup>	P-value*
N	13416	36766	33281	
Age (year)	21.88±4.17	21.56±4.06	21.28±3.87	<0.001
Weight (kg)	62.66 ±14.07	64.19 ±14.14	65.14 ±13.93	<0.001
BMI (kg/m <sup>2</sup> )	22.38 ±4.05	22.57 ±4.02	22.53 ±4.03	<0.001
Gender (male) (%)	36.8	43.6	50.7	<0.001
Marital status (married) (%)	12.3	11.2	8.0	<0.001
Education (graduate) (%)	43.1	39.7	35.9	<0.001
Breakfast skipper (%)	50.9	47.3	41.6	<0.001
Current smoker (%)	11.5	7.5	9.6	<0.001
Sleep pattern (regular) (%)	49.9	59.7	62.9	<0.001
Overweight or obesity (%)	22.0	23.3	22.1	<0.001
Occupation (%)	10.7	9.5	10.4	<0.001
Supplement use (%)	10.3	9.4	10.7	<0.001
Hypertension (%)	8.6	5.5	7.7	<0.001
Good economic status (%)	81.3	83.6	82.7	
Net-connected devices (frequent use) (%)	25.2	21.6	21.2	<0.001
Primary headaches (%)	11.7	8.9	8.1	<0.001
Dietary intakes				
Fruits (>1 serv/d) (%)	53.3	62.4	66.4	<0.001
Vegetables (daily) (%)	10.6	12.6	16.3	<0.001
Dairy products (daily) (%)	19.5	22.4	27.8	<0.001
Fast foods (daily) (%)	1.7	0.9	1.2	<0.001
SSBs (daily) (%)	6.9	5.5	6.8	<0.001
Sweets (daily) (%)	14.5	11.1	13.7	<0.001

Data are presented as mean (SD) or percent

Abbreviation: BMI: body mass index, SSBs: sugar-sweetened beverages

<sup>1</sup>a-30 minute physical activity with a moderate-to-high severity ≥3 times/wk

<sup>2</sup>a-30 minute physical activity with a moderate-to-high severity 1-2 times/wk

<sup>3</sup>a-30 minute physical activity with a moderate-to-high severity <1 time/wk or rarely

\*Obtained from the ANOVA or Chi-square, where appropriate

2: Multivariable-adjusted ORs and 95% CIs for primary headaches across the categories of physical activity

	Inactive <sup>1</sup>	Moderate <sup>2</sup>	Active <sup>3</sup>	P-trend*
Crude	1.00	0.73 (0.69-0.78)	0.66 (0.62-0.71)	<0.001
Model 1	1.00	0.76 (0.71-0.81)	0.71 (0.66-0.76)	<0.001
Model 2	1.00	0.80 (0.74-0.87)	0.75 (0.69-0.82)	<0.001
Model 3	1.00	0.84 (0.78-0.92)	0.80 (0.73-0.87)	<0.001
Model 4	1.00	0.84 (0.77-0.91)	0.79 (0.72-0.87)	<0.001

presented as OR (95% CI)

tion: OR: odds ratio, CI: confidence interval, wk: week, SSBs: sugar-sweetened beverages, BMI: body mass index

nute physical activity with a moderate-to-high severity ≥3 times/wk

nute physical activity with a moderate-to-high severity 1-2 times/wk

nute physical activity with a moderate-to-high severity <1 time/wk or rarely

: adjusted for age and gender

: additionally adjusted for marital status, education, occupation, economic status, smoking, the use internet-connected devices, sleep pattern, tension, supplement use, and breakfast skipping

: further adjustment for dietary intake of fruits, vegetables, dairy products, fast foods, SSBs, and sweets

: more adjustment for BMI

d from binary logistic regression

Multivariable-adjusted ORs and 95% CIs for primary headaches across the categories of physical activity stratified based on gender and BMI

	Inactive	Moderate	Active	P-trend*
ever				
smokes				
Crude	1.00	0.75 (0.67-0.84)	0.59 (0.52-0.66)	<0.001
Model 1	1.00	0.74 (0.66-0.83)	0.58 (0.52-0.65)	<0.001
Model 2	1.00	0.81 (0.70-0.93)	0.64 (0.55-0.74)	<0.001
Model 3	1.00	0.87 (0.75-1.01)	0.71 (0.60-0.83)	<0.001
Model 4	1.00	0.87 (0.75-1.01)	0.70 (0.60-0.82)	<0.001
males				
Crude	1.00	0.75 (0.70-0.81)	0.78 (0.72-0.84)	<0.001
Model 1	1.00	0.76 (0.70-0.82)	0.79 (0.72-0.85)	<0.001
Model 2	1.00	0.79 (0.72-0.88)	0.82 (0.73-0.91)	0.001
Model 3	1.00	0.83 (0.75-0.91)	0.85 (0.76-0.94)	0.008
Model 4	1.00	0.81 (0.73-0.90)	0.84 (0.75-0.94)	0.006
status				
normal-weight (BMI<25 kg/m <sup>2</sup> )				
Crude	1.00	0.72 (0.67-0.78)	0.65 (0.61-0.71)	<0.001
Model 1	1.00	0.75 (0.70-0.81)	0.71 (0.65-0.76)	<0.001
Model 2	1.00	0.79 (0.72-0.86)	0.75 (0.68-0.83)	<0.001
Model 3	1.00	0.83 (0.75-0.91)	0.79 (0.71-0.87)	<0.001
overweight/obese (BMI≥25 kg/m <sup>2</sup> )				
Crude	1.00	0.73 (0.64-0.83)	0.65 (0.57-0.75)	0.023
Model 1	1.00	0.75 (0.65-0.86)	0.68 (0.59-0.78)	0.001
Model 2	1.00	0.82 (0.69-0.98)	0.73 (0.61-0.88)	0.028
Model 3	1.00	0.87 (0.72-1.33)	0.80 (0.66-0.96)	<0.001

presented as OR (95% CI)

\*definition: OR: odds ratio, CI: confidence interval, wk: week, SSBs: sugar-sweetened beverages, BMI: body mass index

: moderate physical activity with a moderate-to-high severity ≥3 times/wk

: moderate physical activity with a moderate-to-high severity 1-2 times/wk

: moderate physical activity with a moderate-to-high severity <1 time/wk or rarely

: adjusted for age and gender (only included to BMI status-stratified analysis)

: additionally adjusted for marital status, education, occupation, economic status, smoking, the use of internet-connected devices, sleep pattern, television, supplement use, and breakfast skipping

: further adjustment for dietary intake of fruits, vegetables, dairy products, fast foods, SSBs, and sweets

: more adjustment for BMI (only included to gender-stratified analysis)

d from binary logistic regression