Original Article

Dietary patterns and smartphone use in adolescents in Korea: A nationally representative cross-sectional study

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Background and Objectives: Diet and smartphone use are daily routines that can affect adolescents' mental health. This study investigated whether the frequency of the consumption of certain foods is associated with the duration of smartphone use and problems caused by smartphone overuse in adolescents. **Methods and Study Design:** Food consumption and smartphone use were investigated in 62,276 Korean adolescents aged 12–18 years by using a nationwide self-report survey. Food intake was assessed on a seven-point scale ("never" to "1, 2, and 3 or more times per day") for nine items: fruits, vegetables, milk, soda, energy drinks, sweetened beverages, fast food, instant noodles, and snacks. The durations of smartphone use and problematic use were determined using self-report items. **Results:** Most respondents (66.5%) used smartphones over 2 hours per day. Higher consumption levels of fruits (F=151.8; p<0.001), vegetables (F=119.9; p<0.001), and milk (F=33.0; p<0.001) were associated with significantly lower smartphone usage, whereas higher consumption levels of soda (F=292.5; p<0.001), energy drinks (F=24.0; p<0.001), sweetened beverages (F=224.8; p<0.001), fast food (F=192.1; p<0.001), instant noodles (F=196.2; p<0.001), and snacks (F=131.6; p<0.001) were positively associated with higher smartphone usage. **Conclusions:** Our findings provide useful clinical information regarding the association between dietary habits and smartphone use in adolescents. Future studies should investigate underlying mechanisms and examine the efficacy of dietary interventions for adolescents with excessive smartphone use.

Key Words: adolescents, dietary patterns, smartphone use, addictive potential, sensation seeking

INTRODUCTION

Adolescence is a period in which significant emotional, cognitive, and behavioral developmental changes occur, and these changes are strongly influenced by various social factors at individual, family, community, and national levels.[1] Notably, the mental health of adolescents is associated with various daily health-related behaviors such as sleep, physical activity, diet, screen time, substance abuse, and school violence.[2-7]

Since the unveiling of the iPhone in 2007, smartphones have rapidly penetrated the daily life of both adolescents and adults and have become a critical daily routine in the lives of adolescents.[8] In 2015, 92% of teens reported to go online daily, and only 8% of teens went online less than once per day.[9] In 2018, 95% of US adolescents were reported to own a smartphone or have access to one, and 45% of teens were online on a near-constant basis.[10] Studies have suggested that excessive smartphone use is associated with unfavorable outcomes for adolescents' mental health, leading to depression and anxiety.[11,12]

Problematic or maladaptive use of smartphones among adolescents has rapidly become a widespread social concern.[13] A consensus has not yet been reached regarding smartphone addiction in adolescence, which has led to the use of various methodologies and concepts in research on this phenomenon, including addiction, dependence, problematic use, and abuse.[13] Despite the lack of conceptual delimitation, several studies have reported substantial concerns regarding smartphone addiction, with a wide prevalence range of 0.4% to 64%.[13] Among various biopsychosocial factors related to addictive disorders, impulsivity and sensation seeking are considered central characteristics predicting smartphone abuse.[14-16]

Dietary habits are another crucial daily routine associated with adolescents' mental health. Eating was originally considered a hedonic behavior that stimulates the brain reward circuit. However, the framing of addictive-like eating problems as "eating addiction" or "food addiction" is controversial.[17,18] The framework of "eating addiction" suggests a behavioral addiction triggering an addictive-like response in susceptible individuals, whereas the

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"food addiction" model focuses on the questions of whether certain foods provoke more addictive-like eating behavior compared with other foods. Several studies have reported that some types of food might cause neurobiological changes more than other foods, thereby provoking addictive-like eating.[19] For instance, frequent consumption of highly processed food with high fat, salt, and sugar content, such as soda, pizza, and snacks, increases individuals' impulsivity and food cravings.[20-23] By contrast, the Mediterranean diet, which includes fiber-rich fruits and vegetables, was reported to reduce impulsivity.[24]

The overuse of smartphones and the high consumption of specific dietary contents have been suggested to share a neurobiological mechanism that may be associated with addictive-like behavior. However, to our knowledge, studies examining the direct association between smartphone overuse and specific dietary patterns are lacking. Therefore, we investigated whether the frequency of the consumption of specific foods is associated with smartphone usage time and problems caused by smartphone overuse.

METHODS

Participants

Data from the 2017 Korean Youth Risk Behavior Web-based Survey (KYRBS), a nationwide, self-reported, cross-sectional study conducted by the Korean Centers for Disease Control and Prevention, were analyzed.[25] The target population for the 2017 survey was 64,991 nationally representative students aged 12–18 years attending 400 middle schools and 400 high schools in Korea. A total of 62,276 (95.8%) adolescents participated in the survey. The detailed process is described in Supplementary figure 1. Before participating in the survey, the students signed an online informed consent form. The steering committee representing the Office of Education from 17 provinces of Korea oversaw the survey. The Institutional Review Board of Dankook University Hospital (DKUH 2019-07-022) approved the study. The use of data from the 2017 KYRBS (KYRBS repository, https://yhs.cdc.go.kr) was permitted by the Korea Centers for Disease Control and Prevention.

Assessment

A self-rated questionnaire consisting of nine items (fruits, vegetables, milk, soda, caffeinated energy drinks, sweetened beverages, fast food [i.e., pizza, hamburgers, and fried chicken], instant noodles, and snacks) was used to assess the food intake frequency. Consumption of each item was rated on a seven-point rating scale (never, 1 to 2, 3 to 4, and 5 to 6 times per week and 1, 2, and more than 3 times per day).

Smartphone usage time was assessed using the following item: "How many hours and minutes per day have you used a smartphone in the last 30 days?" Smartphone usage time was categorized into weekdays and weekends, and the average daily hours of use on weekdays and weekends were used in the subsequent analysis.

Conflicts with the family and disturbances in school performance caused by smartphone use were assessed using the following items, which were rated on a four-point Likert scale (1=strongly disagree to 4=strongly agree): "I have experienced severe conflicts with my family because of smartphone use" and "Because of the use of smartphones, I have difficulties in carrying out my studies." In our study, the high-risk group for problems caused by smartphone use was defined as those responding agree or strongly agree to each item.

The students were provided detailed instructions for the study by trained teachers before completing the survey. The students who agreed to participate responded to an anonymous, self-administered, web-based questionnaire presented on a computer screen.

Statistical analysis

Smartphone usage time and problems caused by smartphone use were compared among different food intake frequency groups. In the comparison of smartphone usage time, the groups "1, 2, and more than 3 times per day" were merged into one group of "more than 1 time," because of the small proportion of participants in those frequency groups. Differences in smartphone usage time among the food intake frequency groups were analyzed using three models. Model 1 was analyzed using ANOVA, with the consumption frequency of each type of food as the independent variable and smartphone usage time as the dependent variable, whereas Model 2 was analyzed using ANCOVA, with sex, age, and socioeconomic status as covariates. Model 3 included parental educational levels as covariates, in addition to those used in Model 2. In Model 2, post-hoc analyses were performed using Tukey's honest significant difference test, because of the numerous missing values for the parental educational level. The OR for the groups at high risk of conflict with family and disturbances in school performance caused by excessive smartphone use was analyzed using a logistic regression model with the categories of foods as independent variables. Statistical analyses were performed using the software package SPSS 25.0 for Windows (IBM Corp., Armonk, NY, USA).

RESULTS

Demographic characteristics

The demographic characteristics of the participants are presented in Table 1. Among the 62,276 participating adolescents, 31,624 (50.8%) were boys. A small proportion of adolescents (12.3%) had not used a smartphone in the past 30 days. Two-thirds (66.5%) used a smartphone for over 2 hours per day, and 5.3% used a smartphone for more than 10 hours per day.

Association between food intake frequency and smartphone usage time

The food intake frequencies are listed in Table 2. Responses of "1 to 2 times per week" were the most prevalent for fruits, milk, soda, sweetened beverages, fast food, instant noodles, and snacks; "3 to 4 times per week" was the most prevalent response for vegetables; and "never" was the most prevalent response for caffeinated energy drinks. The rates of responses of "2 times per day" and "more than 3 times per day" were considerably low (under 2%) for soda, caffeinated energy drinks, sweetened beverages, fast food, instant noodles, and snacks.

Table 3 and Figure 1 present the association between

Table 1. Demographics characteristics

	n (%)
Sex	
Male	31624 (50.8)
Female	30652 (49.2)
Age	
12	4987 (8.0)
13	10280 (16.5)
14	10286 (16.5)
15	10335 (16.6)
16	10707 (17.2)
17	10874 (17.5)
18	4392 (7.1)
unknown	415 (0.7)
Smartphone usage time (h)	
Never	7675 (12.3)
<1	3551 (5.7)
1≤h<2	9627 (15.5)
2≤h<4	21305 (34.2)
4≤h<6	10500 (16.9)
6≤h<8	4377 (7.0)
8≤ h<10	1957 (3.1)
≥10	3284 (5.3)
Problems caused by smartphone use	
Conflicts with family	
Strongly disagree	24265 (44.4)
Disagree	18337 (33.6)
Agree	10365 (19.0)
Strongly agree	1636 (3.0)
Disturbances in school performance	
Strongly disagree	25585 (46.9)
Disagree	15545 (28.5)
Agree	11374 (20.8)
Strongly agree	2099 (3.8)
Socioeconomic status	
High	6713 (10.8)
High-middle	18089 (29.0)
Middle	28582 (45.9)
Low-middle	7299 (11.7)
Low	1593 (2.6)
Paternal educational level	
≤12 years	17094 (27.4)
>12 years	31535 (50.6)
Unknown	13647 (21.9)
Maternal educational level	
≤12 years	20436 (32.8)
>12 years	29005 (46.6)
Unknown	12835 (20.6)

Table 2. Food intake frequency

n (%)	Never	1-2 times/week	3-4 times/week	5-6 times/week	1 or more than 3 times/day
Fruit	6242 (10.0)	18361 (29.5)	16903 (27.1)	7014 (11.3)	13754 (22.1)
Vegetable	2597 (4.2)	9893 (15.9)	14886 (23.9)	8605 (13.8)	26295 (42.2)
Milk	9047 (14.5)	15468 (24.8)	13064 (21.0)	8726 (14.0)	15970 (25.6)
Soda	13042 (20.9)	28381 (45.6)	13796 (22.2)	3774 (6.1)	3283 (5.3)
caffeinated energy drink	47435 (76.2)	9969 (16.0)	2962 (4.8)	835 (1.3)	1075 (1.7)
sweetened beverage	7810 (12.5)	25300 (40.6)	17913 (28.8)	6052 (9.7)	5201 (8.4)
Fastfood	12646 (20.3)	37225 (59.8)	9991 (16.0)	1599 (2.6)	815 (1.3)
Instant noodle	13836 (22.2)	32139 (51.6)	12542 (20.1)	2503 (4.0)	1256 (2.0)
Snack	10218 (16.4)	27415 (44.0)	17219 (27.6)	4339 (7.0)	3085 (5.0)

the food intake frequency and smartphone use time. Higher consumption levels of fruits (F=151.8; p<0.001), vegetables (F=119.9; p<0.001), and milk (F=33.0; p<0.001) were associated with significantly lower smartphone usage. By contrast, higher consumption levels of soda (F=292.5; p<0.001), energy drinks (F=24.0; p<0.001), sweetened beverages (F=224.8; p<0.001), fast food (F=192.1; p<0.001), instant noodles (F=196.2; p<0.001), and snacks (F=131.6; p<0.001) were associated with higher smartphone usage.

Table 3. Smartphone usage time among the groups of food intake frequency (hours per day)

Food	Never	1-2 times/week	3-4 times/week	5-6 times/week	1 or more than 1 time/day	Statistics (F) †			post-hoc‡
						Model 1	Model 2	Model 3	
Fruit	4.22 (4.02)	3.81 (3.51)	3.48 (3.22)	3.36 (3.18)	3.13 (3.14)	151.8**	98.1**	54.6**	a>b>c=d>e
Vegetable	4.38 (4.20)	3.98 (3.66)	3.66 (3.35)	3.41 (3.21)	3.31 (3.24)	119.9**	29.7**	20.4**	a>b>c>d=e
Milk	3.81 (3.63)	3.62 (3.34)	3.61 (3.38)	3.54 (3.34)	3.33 (3.32)	33.0**	5.1**	3.2*	a>b=c=d>e
Soda	3.03 (2.99)	3.39 (3.12)	3.92 (3.59)	4.22 (3.9)	4.83 (4.75)	292.5**	112.0**	77.4**	a<b<c<d<e
Caffeinated energy drink	3.49 (3.27)	3.73 (3.61)	3.83 (3.71)	3.99 (4.21)	4.01 (4.64)	24.0**	3.7*	2.6*	a<c,d,e
Sweetened beverage	3.00 (3.14)	3.30 (3.12)	3.73 (3.37)	4.07 (3.70)	4.44 (4.29)	224.8**	50.3**	37.8**	a<b<c<d<e
Fastfood	3.09 (3.08)	3.50 (3.26)	4.16 (3.78)	4.32 (4.19)	4.77 (5.12)	192.1**	23.0**	17.6**	a<b<c=d<e
Instant noodle	3.19 (3.17)	3.43 (3.19)	3.99 (3.64)	4.48 (4.18)	4.83 (4.96)	196.2**	55.5**	41.2**	a<b<c<d<e
Snack	3.24 (3.26)	3.42 (3.26)	3.66 (3.36)	4.11 (3.68)	4.53 (4.34)	131.6**	11.8**	10.8**	a<b<c<d<e

†Model 1 is crude model with the consuming frequency of each kind of food as independent variables and smartphone use time as the dependent variable.
Model 2 is adjusted model including sex, age, and socioeconomic status as covariates in addition to model 1.
Model 3 included parental educational levels as covariates in addition to model 2.
‡post-hoc: a (never), b (1-2 times/week), c (3-4 times/week), d (5-6 times/week), e (1 or more than 1 time/day).
*p<0.05; **p<0.001.

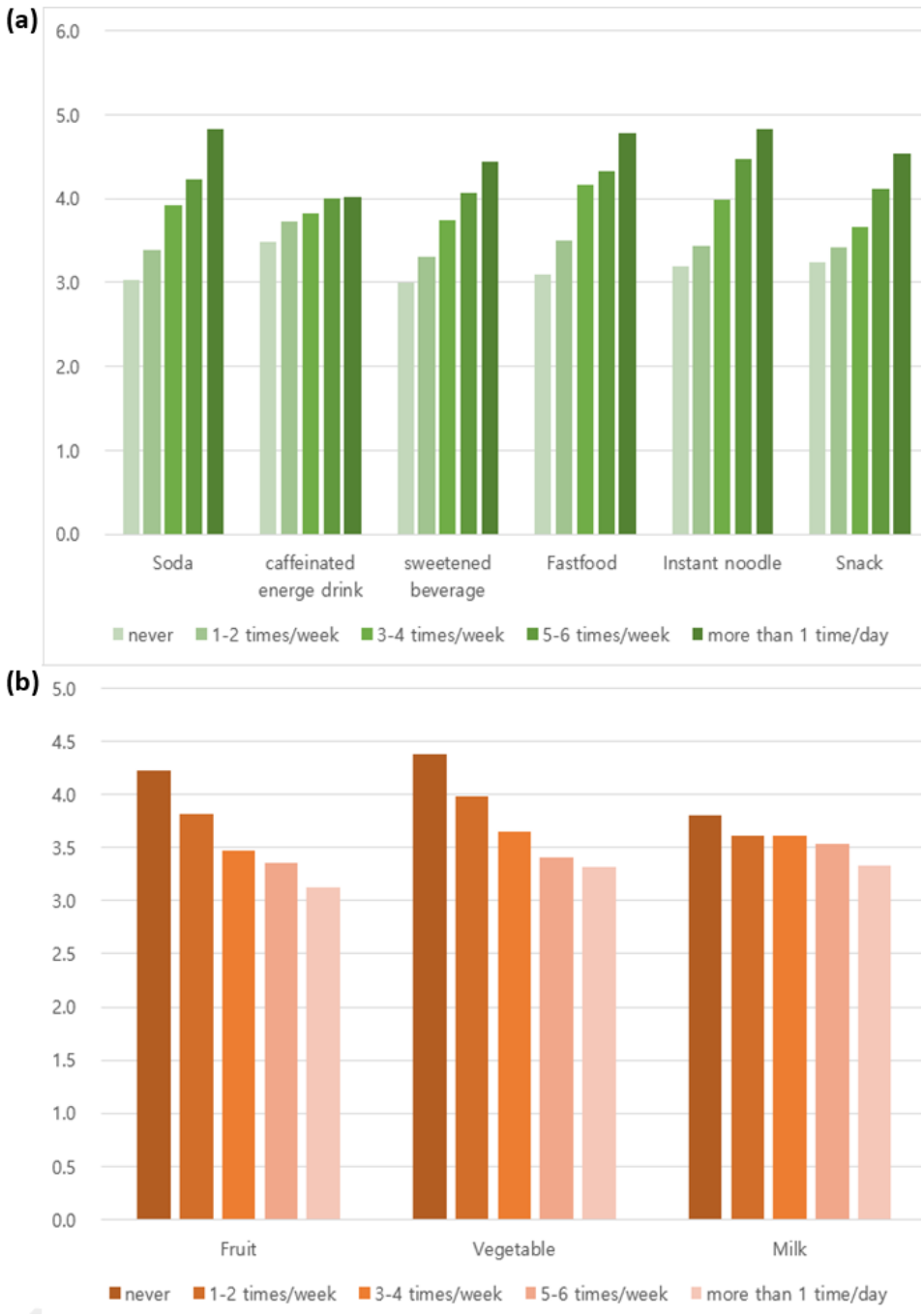

Figure 1. Smartphone usage time among the groups of food intake frequency (hours per day).

Association between food intake frequency and problems caused by smartphone use

The OR for the groups at high risk of conflict with family and disturbances in school performance caused by excessive smartphone use increased with more frequent consumption of soda, caffeinated energy drinks, sweetened beverages, fast food, instant noodles, and snacks (Table 4). The ORs also increased with less frequent vegetable intake. However, a higher intake frequency of fruit was more strongly associated with an increased OR for conflict with family, whereas milk was not significantly associated with the OR for conflict with family.

The scores for items related to problems caused by smartphone use differed significantly among the food intake frequency groups (Supplementary table 1). Higher consumption levels of fruits, vegetables, and milk and lower consumption levels of soda, caffeinated energy drinks, sweetened beverages, fast food, instant noodles, and snacks were significantly associated with fewer problems caused by smartphone use. However, the average scores for items related to problems caused by smartphone use were <2 (“disagree”) in all food intake frequency groups.

DISCUSSION

The present study investigated the association between excessive smartphone use and dietary habits by using a cross-sectional design in a large sample of Korean adolescents. Most participating adolescents (87.7%) reported having used a smartphone in the past 30 days, and 66.5% reported using a smartphone for over two hours per day. These findings reflect the pervasive use of smartphones

Table 4. Odds ratio for the high risk group of problems caused by smartphone use according to the food intake frequency

	Conflict with family			Disturbances in school performance		
	Soda	Saffeinated energy drink	Sweetened beverage	Soda	Caffeinated energy drink	Sweetened beverage
Never	referent	referent	referent	referent	referent	referent
1-2 times/week	1.03 (0.97 to 1.09)	1.10 (1.04 to 1.16)**	1.06 (0.98 to 1.14)	0.95 (0.90 to 1.00)	1.00 (0.95 to 1.06)	1.09 (1.01 to 1.17)*
3-4 times/week	1.05 (0.98 to 1.13)	1.07 (0.98 to 1.18)	1.12 (1.04 to 1.21)**	0.88 (0.82 to 0.94)**	1.12 (1.02 to 1.23)*	1.15 (1.07 to 1.24)**
5-6 times/week	1.05 (0.95 to 1.15)	1.20 (1.01 to 1.42)*	1.09 (0.99 to 1.20)	0.80 (0.73 to 0.89)**	1.36 (1.15 to 1.60)**	1.15 (1.05 to 1.26)**
1 or more than 1 time/day	0.99 (0.89 to 1.11)	1.18 (1.01 to 1.38)*	1.09 (0.98 to 1.20)	0.74 (0.66 to 0.82)**	1.13 (0.96 to 1.32)	1.28 (1.16 to 1.41)**
	Fastfood	Instant noodle	Snack	Fastfood	Instant noodle	Snack
Never	referent	referent	referent	referent	referent	referent
1-2 times/week	1.06 (1.00 to 1.12)*	1.10 (1.05 to 1.17)**	1.14 (1.06 to 1.21)**	1.18 (1.11 to 1.24)**	1.06 (1.00 to 1.11)*	1.15 (1.08 to 1.22)**
3-4 times/week	1.21 (1.12 to 1.30)**	1.27 (1.19 to 1.36)**	1.33 (1.24 to 1.43)**	1.44 (1.34 to 1.55)**	1.03 (0.97 to 1.10)	1.47 (1.38 to 1.57)**
5-6 times/week	1.15 (1.01 to 1.32)*	1.40 (1.25 to 1.56)**	1.65 (1.50 to 1.81)**	1.72 (1.51 to 1.96)**	0.92 (0.82 to 1.02)	1.77 (1.62 to 1.94)**
1 or more than 1 time/day	1.22 (1.01 to 1.48)*	1.45 (1.24 to 1.69)**	1.63 (1.47 to 1.81)**	1.66 (1.37 to 2.02)**	0.88 (0.75 to 1.04)	1.76 (1.59 to 1.94)**
	Fruit	Vegetable	Milk	Fruit	Vegetable	Milk
1 or more than 1 time/day	referent	referent	referent	referent	referent	referent
5-6 times/week	0.93 (0.87 to 1.00)	1.04 (0.98 to 1.11)	1.04 (0.97 to 1.11)	1.06 (0.99 to 1.14)	1.00 (0.94 to 1.07)	1.10 (1.03 to 1.18)**
3-4 times/week	0.86 (0.81 to 0.92)**	1.06 (1.00 to 1.12)*	1.06 (0.99 to 1.12)	1.03 (0.97 to 1.09)	1.13 (1.08 to 1.19)**	1.29 (1.21 to 1.36)**
1-2 times/week	0.83 (0.78 to 0.88)**	1.19 (1.12 to 1.27)**	1.04 (0.98 to 1.11)	1.09 (1.03 to 1.16)**	1.29 (1.21 to 1.36)**	1.30 (1.23 to 1.38)**
Never	0.86 (0.80 to 0.93)**	1.30 (1.17 to 1.44)**	1.03 (0.96 to 1.11)	1.10 (1.02 to 1.19)*	1.52 (1.38 to 1.67)**	1.32 (1.23 to 1.41)**

*p<0.05; **p<0.001.

among adolescents. In studies conducted in the United States, 92% of teens reported going online daily and 45% reported being online "almost constantly;" these findings are comparable with those of the present study.[9,10]

The major finding of the present study is the significant association between specific dietary patterns and smartphone usage time. Higher consumption levels of soda, sweetened beverages, highly caffeinated drinks, fast food, instant noodles, and snacks, all of which could be labeled as addictive food, were associated with higher use of smartphones among adolescents. By contrast, a higher intake of fruits and vegetables was linearly associated with a lower level of smartphone usage. A higher intake of milk was also associated with lower smartphone usage, although the association was weaker than that with fruits and vegetables. To our knowledge, the association between smartphone use and dietary habits in adolescents has not been previously investigated. The linearity of the association between the consumption frequency of specific foods and smartphone usage time is particularly noteworthy, although the effect size of the association is small. Studies have reported associations between psychiatric symptoms and dietary patterns in disorders characterized by impulsivity and vulnerability to addiction, such as attention-deficit/hyperactivity disorder (ADHD),[26-28] binge-eating disorder,[29] and gambling,[30] which accords with the present findings. For instance, Kim et al reported linear associations between ADHD symptom (hyperactivity and inattention) scores and the consumption frequency of specific foods among school-aged children.[27]

The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders included internet gaming disorder in the "Conditions for Further Study" section.[31] Furthermore, gaming disorder was listed as a formal diagnosis in the International Classification of Diseases, 11th Revision, released in 2018.[32] Although excessive smartphone use is yet to be classified as a formal mental disorder, the addictive potential of excessive smartphone use warrants further investigation, considering that internet gaming is one of the major uses of smartphones and that smartphones are widely accessible at any time. Impulsivity and altered reward circuit activation in the brain are shared neurobiological features in disorders that increase vulnerability to addiction, such as ADHD and substance abuse.[33,34] These neurobiological features are also the major predictive dimensions of excessive smartphone use,[13,35] and dietary patterns affect impulsivity and reward circuit activation.[18]

Although the concept of food addiction is controversial and a consensus has not been reached on whether humans display addictive-like eating,[37] animal studies have indicated that the high consumption levels of high-fat and high-sugar foods induce neurobiological changes, such as dysfunction of the reward system and downregulation of dopamine receptors, which are also observed in other addictive disorders.[18,37,38] Human studies have also reported the addictive potential of hyperpalatable food because of neural activation in addictive-like eating behavior and substance dependence (e.g., activation in the reward circuit).[19,37,39,40]

Contrary to addictive, high-fat, high-sugar, and highly processed foods, the Mediterranean diet, which is rich in fruits and vegetables, was reported to be negatively associated with impulsivity and sensation seeking.[41] Food addictions are also associated with a lower intake of the Mediterranean diet,[36] which accords with the findings of the present study. Although several studies have suggested a protective association of fruit and vegetable intake with impulsivity and vulnerability to addiction, the underlying mechanism has not been clarified. However, some possible mechanisms have been suggested. For instance, phytochemicals and short-chain fatty acids in as well the antioxidant properties of fruits and vegetables have been reported to exert neuroprotective effects.[42]

Although dietary patterns showed a significant linear association with smartphone usage time in our study, they do not necessarily cause smartphone "addiction" directly. Factors other than excessive use, such as social impairment, tolerance, and failure to control behavior, are also be needed to be classified as a diagnosis of addiction.[13] Our study revealed relatively inconsistent associations in ORs for problems caused by smartphone use among the food intake frequency groups compared with a linear association between dietary habits and smartphone usage time. These findings may suggest that the effect of dietary patterns on smartphone use is not strong enough to warrant labeling as a smartphone addiction; however, diet may contribute to vulnerability to addiction by changing the underlying neural mechanism of the reward circuit activation. Studies have reported consistent findings regarding the addictive potential of foods. In a systematic review of food addiction, many included articles reported that food intake could cause brain reward system dysfunction (21 studies) and impaired control (12 studies), which indicates the existence of a change in neurobiological function caused by dietary habits.[19] However, only two studies have reported evidence for social impairment caused by "food addiction."[19] The findings of these studies suggest that the negative affect of food addiction on social impairment is less evident, compared to the neurobiological change by food addiction, which accords with our findings.

Limitations

This study has some limitations that should be noted. First, a cross-sectional design was employed that limits the ability to determine causal relationships. Children and adolescents who are vulnerable to addiction and whose sensation seeking and impulsive temperament are high may share the common features of smartphone overuse and frequent intake of addictive food. However, previous studies have reported that dietary intervention can change core symptoms in children with ADHD. Moreover, Lumley et al. reported that higher impulsivity was associated with the consumption of a Western-style diet, with bidirectional causation.[43] These findings indicate that long-term dietary patterns may affect smartphone usage. However, longitudinal or experimental studies are required to confirm the exact causal relationship.

Second, our study was based on an anonymous, self-reported questionnaire, and the adolescents might have inaccurately reported their dietary patterns and smartphone use. Furthermore, we included items to evaluate problems caused by smartphone use. However, validated tools to assess the severity of smartphone abuse

based on addiction criteria were not adopted in our study. Therefore, future studies should include multi-informant reports and objective measures to assess children's behavior and confirm the findings of our study. However, a study on the correspondence between adolescents' and parents' reports for psychiatric symptoms revealed that adolescents' reports of substance abuse were more accurately correlated with the real diagnosis compared with parents' reports,[44] which mitigate the concerns for the incorrect report from the participating adolescents.

Finally, our study was performed using a typically developing population, which limits the generalizability of findings to populations with addictive psychopathologies, such as ADHD, substance abuse, and eating disorders. Thus, studies in groups with psychiatric disorders are warranted.

Conclusions

Diet is a major but modifiable daily routine in adolescents, and dietary interventions could be improved by understanding psychological characteristics related to consuming each type of food. Despite several limitations, our study is the first to reveal a relationship between dietary patterns and smartphone overuse in a large sample of adolescents. The linear relationships between dietary patterns and smartphone overuse are noteworthy. The smartphone is a critical environmental factor today that induces considerable concerns for adolescents' mental health at the family and societal level. Although dietary habits are not a critical contributor to smartphone addiction, interventions that consider both diet and smartphone use could improve adolescents' mental health.

AUTHOR DISCLOSURES

The author has no conflict of interest relevant to this publication.

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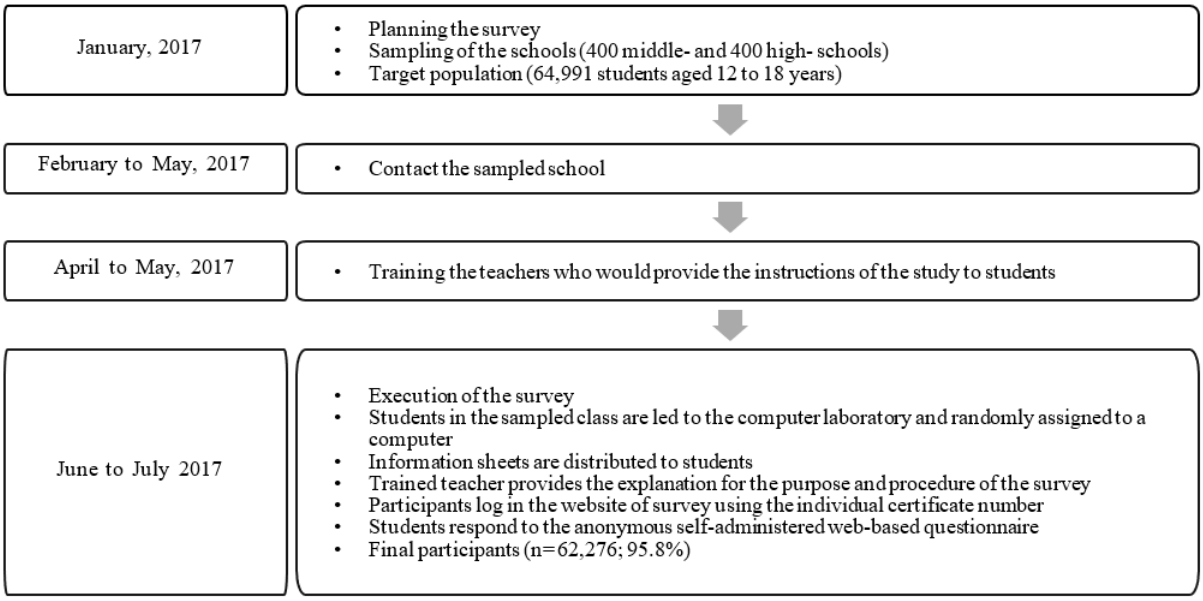

Supplementary figure 1. The flow chart of the study procedure.

Supplemental table 1. Association between food intake frequency and problems caused by smartphone overuse

Food	Never	1-2 times/week	3-4 times/week	5-6 times/week	1 time/day	2 times/day	3 or more times/day	F
Fruit								
Conflict with family	1.8 (0.87)	1.8 (0.84)	1.8 (0.83)	1.8 (0.84)	1.8 (0.86)	1.9 (0.87)	1.8 (0.88)	6.6*
Disturbances in school performance	1.8 (0.92)	1.8 (0.9)	1.8 (0.88)	1.8 (0.90)	1.8 (0.88)	1.8 (0.89)	1.7 (0.89)	14.2*
Vegetable								
Conflict with family	1.9 (0.92)	1.9 (0.86)	1.8 (0.84)	1.8 (0.83)	1.8 (0.84)	1.8 (0.84)	1.7 (0.85)	23.2*
Disturbances in school performance	2.0 (0.99)	1.9 (0.91)	1.9 (0.89)	1.8 (0.86)	1.8 (0.88)	1.8 (0.89)	1.7 (0.87)	78.1*
Milk								
Conflict with family	1.8 (0.85)	1.8 (0.84)	1.8 (0.84)	1.8 (0.85)	1.8 (0.84)	1.8 (0.85)	1.8 (0.9)	7.1*
Disturbances in school performance	1.8 (0.92)	1.9 (0.90)	1.9 (0.89)	1.8 (0.88)	1.7 (0.87)	1.7 (0.87)	1.6 (0.88)	43.8*
	Never	1-2 times/week	3-4 times/week	5-6 times/week	1 or more times/day			
Soda								
Conflict with family	1.7 (0.83)	1.8 (0.84)	1.9 (0.84)	1.9 (0.88)	1.9 (0.92)			37.9*
Disturbances in school performance	1.8 (0.89)	1.8 (0.89)	1.8 (0.89)	1.8 (0.9)	1.8 (0.93)			10.6*
caffeinated energe drink								
Conflict with family	1.8 (0.84)	1.9 (0.85)	1.9 (0.86)	1.9 (0.92)	1.9 (0.96)			24.4*
Disturbances in school performance	1.8 (0.89)	1.8 (0.89)	1.9 (0.92)	2.0 (0.95)	1.9 (0.97)			17.1*
sweetened beverage								
Conflict with family	1.7 (0.82)	1.8 (0.83)	1.8 (0.85)	1.9 (0.87)	1.9 (0.90)			50.5*
Disturbances in school performance	1.7 (0.88)	1.8 (0.88)	1.8 (0.89)	1.9 (0.91)	1.9 (0.94)			37.4*
Fastfood								
Conflict with family	1.7 (0.83)	1.8 (0.84)	1.9 (0.87)	1.9 (0.92)	1.9 (0.99)			73.1*
Disturbances in school performance	1.7 (0.86)	1.8 (0.88)	1.9 (0.93)	2.0 (0.97)	1.9 (1.02)			99.5*
Instant noodle								
Conflict with family	1.7 (0.83)	1.8 (0.83)	1.9 (0.86)	2.0 (0.9)	1.9 (0.96)			92.8*
Disturbances in school performance	1.8 (0.88)	1.8 (0.89)	1.9 (0.9)	1.9 (0.91)	1.8 (0.97)			25.0*
Snack								
Conflict with family	1.7 (0.82)	1.8 (0.82)	1.9 (0.85)	2.0 (0.9)	2.0 (0.94)			128.4*
Disturbances in school performance	1.7 (0.86)	1.8 (0.87)	1.9 (0.9)	2.0 (0.95)	2.0 (0.98)			143.3*

The data is presented as mean value (standard deviation).
*$p<0.001$.