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Smartphone Usage Patterns and Dietary Risk Factors in Adolescents

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ABSTRACT

Background: Whereas earlier studies have shown that traditional screen time such as TV watching influences dietary behaviors in adolescents, little is known about the effects of modern screen time such as smartphone use.

Objectives: We examined the associations of smartphone usage duration and content type with dietary risk factors among adolescents.

Methods: We conducted a cross-sectional analysis using a nationally representative sample of 54,601 middle- and high-school students (aged 12–18 y; 26,928 boys and 27,673 girls) in the Korea Youth Risk Behavior Web-Based Survey 2017. Smartphone use (average duration and most frequently used content type) and dietary intakes [frequent breakfast skipping; less frequent intakes of fruits and vegetables; more frequent intakes of instant noodles, fast food, chips/crackers, and sugar-sweetened beverages (SSBs)] were self-reported via an online-based questionnaire. Multivariable logistic regression was performed to estimate ORs and 95% CIs for the associations of smartphone usage duration and content type with prevalence of dietary risk factors, adjusting for potential confounders. All analyses accounted for complex survey sampling.

Results: Prolonged smartphone use (≥300 compared with 1–59 min/d) was associated with (OR; 95% CI) higher prevalence of frequent breakfast skipping (1.60; 1.45, 1.76); frequent intakes of instant noodles (1.65; 1.47, 1.84), fast food (1.36; 1.20, 1.53), and SSBs (1.92; 1.75, 2.11); and less frequent intakes of fruits (1.44; 1.30, 1.59) and vegetables (1.32; 1.18, 1.47). Adjusting for usage duration, using smartphones mainly for messenger/e-mail, social networking service (SNS)/forum, and games were associated with less frequent intakes of fruits (OR: 1.21; 95% CI: 1.12, 1.31; OR: 1.28; 95% CI: 1.17, 1.40; and OR: 1.20; 95% CI: 1.10, 1.32, respectively) and vegetables (OR: 1.24; 95% CI: 1.12, 1.37; OR: 1.26; 95% CI: 1.13, 1.40; and OR: 1.25; 95% CI: 1.12, 1.40, respectively) than was using smartphones for education/information search. Using smartphones mainly for messenger/e-mail (OR: 1.24; 95% CI: 1.14, 1.35) and SNS/forum (OR: 1.18; 95% CI: 1.08, 1.29) were also associated with more frequent intake of SSBs.

Conclusions: Our data suggest that both duration and content type of smartphone use are independently associated with dietary risk factors among adolescents. *J Nutr* 2022;00:1–8.

Keywords: screen time, Internet, media, dietary factor, diet, food, nutrition, obesity, teenager, youth

Introduction

Smartphones are handheld mobile devices that provide access to various media contents including videos, music, games, and social media. Many attractive features of smartphones, such as portability and Internet access, have facilitated the rapid uptake of smartphones since their creation (1). The number of smartphone users worldwide has now exceeded 3 billion and is expected to increase over the next few years (2). Despite the increased use of smartphones particularly among adolescents, the effects of smartphone use on adolescent health and related behaviors have not been fully investigated. Whereas earlier studies have shown that traditional screen time such as TV watching is an important factor that influences dietary behaviors and obesity risk in adolescents (3–7), little is known about the effects of modern screen time, particularly smartphone use, on dietary intakes of obesogenic foods. Because smartphones, compared with TVs and computers, allow easier access to a wider range of contents regardless of time and location, smartphones are likely to have a strong influence on adolescent behaviors. While using smartphones, adolescents are likely to be exposed to contents (e.g., food advertisements) that influence their food choices and dietary behaviors (8, 9). Food manufacturers and marketing companies of today utilize digital platforms such as social media (e.g., Facebook, Twitter) and content-sharing platforms (e.g., YouTube) to reach young people, often delivering misleading messages and creating misperceptions of foods (8, 10–14). Prolonged smartphone use

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may also increase sedentary time and thereby influence appetite and cravings for foods (15–17).

In this study, we examined the associations of smartphone usage patterns (duration and content type) with dietary risk factors among adolescent smartphone users. Whereas previous studies primarily focused on smartphone addiction and problematic smartphone use (18–21), we examined a wider range of usage duration and investigated whether the associations were also present in adolescents without smartphone addiction symptoms. We also considered smartphone content types and investigated the independent associations of smartphone usage duration and content type, while carefully controlling for potential confounders such as socioeconomic status. Further, we examined effect modification by obesity and sociodemographic factors that are likely to influence food accessibility and individuals' susceptibility to unhealthful dietary intakes.

Methods

Study population

We conducted a cross-sectional analysis using data from the Korea Youth Risk Behavior Web-Based Survey (KYRBS) 2017. The KYRBS is a series of nationwide cross-sectional surveys conducted by the Korea Disease Control and Prevention Agency (KDCA) every year since 2005 aiming to assess health behaviors of Korean adolescents (aged 12–18 y) (22). A multistage cluster sampling design was used to select a nationally representative sample of Korean middle- and high-school students. In 2017, a total of 62,276 students participated from 799 middle and high schools, with a response rate of 95.8%. The survey was conducted online and collected information on demographic and lifestyle characteristics. Among 62,276 KYRBS 2017 participants, we excluded participants with missing information on dietary variables (n = 2). We also excluded participants who reported not using smartphones during the past 30 d (n = 7673) because these individuals may not have access to smartphones, as well as access to healthy foods. In total, 54,601 adolescents (26,928 boys and 27,673 girls) were included in the analysis (participant flowchart in **Supplemental Figure 1**). All participants provided informed consent and the survey was approved by the Ethics Committee of the KDCA.

Duration and content type of smartphone use

Participants were asked to report the average duration of weekday and weekend smartphone use during the past 30 d. Using this information, we calculated the average daily duration of smartphone use and categorized it into 60-min intervals (1–59, 60–119, 120–179, 180–239, 240–299, ≥300 min/d). Participants were also asked to select the single most frequently used smartphone content type during the past 30 d from the following list: educational contents (e.g., online lectures), information search, messenger chatting (e.g., Kakao Talk, Line), game, movie, Webtoon/Web-novel, music, video (e.g., YouTube, Africa TV), social networking service (SNS) (e.g., blogs, Instagram, Twitter, Facebook), online community forum, e-mail, online shopping, and others. Based on similarities, we collapsed the categories into 7 groups: education/information search, messenger/e-mail, SNS/forum, game, movie/video/music, Webtoon/Web-novel, and shopping/others.

Dietary risk factors

We selected 7 individual dietary risk factors that have previously been shown to be associated with obesity, cardiovascular disease, diabetes, and cancer: frequent breakfast skipping (23–25); less frequent intakes of fruits (excluding fruit juice) (26–29) and vegetables (excluding *kimchi*) (26–28); and more frequent intakes of Korean instant noodles (rameyon) (30), fast food (e.g., pizza, hamburger, fried chicken) (31, 32), chips/crackers (33–35), and sugar-sweetened beverages (SSBs) (e.g., sports drink, fruit juice, carbonated drink, sweetened instant coffee) (29, 36, 37). The frequency of breakfast eating was asked using the following question: "During the past seven days, how many days did you eat breakfast meal, including cereal, porridge, bread, and grain powder (drinking milk or juice does not count)?" For each food group, the frequency of intakes during the past 7 days was reported in the following categories: none, 1–2 times/wk, 3–4 times/wk, 5–6 times/wk, once a day, twice a day, and ≥3 times/d. Carbonated and noncarbonated SSB intakes were combined into a single SSB variable. We converted each dietary variable into a binary dietary risk factor identifying intakes related to high risk, using cutoffs selected based on the frequency intakes specified in the national statistics report and Dietary Reference Intakes for Koreans 2015 (≥5 d/wk breakfast skipping; <1 time/d fruit intake; <3 times/d vegetable intake; ≥3 times/wk fast food, instant noodle, chip/cracker, and SSB intakes) (38).

Statistical analysis

All statistical analyses accounted for the sampling weights and complex sampling design of the survey. We performed weighted multivariable logistic regression to estimate ORs and 95% CIs for the associations of smartphone usage patterns (duration and content type) with prevalence of dietary risk factors. For each dietary risk factor, an OR >1 indicates associations with less healthful dietary intakes. Multivariable models included *a priori* selected potential confounders: sex, grade in school, region, perceived household income, parental co-residence, parents' highest education, average weekly allowance, perceived stress, self-rated health, physical activity, academic performance, and the presence of smartphone addiction symptoms (experienced serious conflicts with family members or friends, or experienced difficulties doing schoolwork due to smartphone use). We also mutually adjusted for all dietary risk factors under study to account for correlations among dietary risk factors. To examine the independent associations of smartphone usage duration and content type, we mutually adjusted for both variables in all models. Additional adjustment for alcohol drinking, smoking, and sleep duration did not change the results and thus these variables were not included in the final models. For smartphone usage duration, we performed tests for linear trend using the Wald test for continuous variables. For content type analysis, we tested for the overall difference among the categories using the global F test. In secondary analyses, we stratified the analyses to assess effect modification by sociodemographic variables (sex, school, perceived household income, parents' highest education level, region, and perceived stress), obesity status [BMI-for-age ≥95th percentile based on the 2017 Korean National Growth Charts (39)], and the presence of smartphone addiction symptoms. We tested for interactions using the Wald test for product terms. In sensitivity analysis, we conducted analyses separately for weekday and weekend smartphone use to assess whether the associations varied by day of smartphone use.

All statistical tests were 2-sided with an α level of 0.05. We also adjusted for multiple testing using Bonferroni correction (7 tests/exposure). All statistical analyses were performed using SURVEY procedures in SAS version 9.4 (SAS Institute Inc.).

Results

Participant characteristics

Among 54,601 study participants, the mean age was 15.1 y (range: 12–18 y). Median smartphone usage duration was 192 min/d (168 min/d in boys, 214 min/d in girls). **Supplemental Table 1** shows the distribution of smartphone usage duration according to content types. Median smartphone usage duration

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Supplemental Figures 1 and 2 and Supplemental Tables 1–8 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/jn/.

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Abbreviations used: KDCA, Korea Disease Control and Prevention Agency; KYRBS, Korea Youth Risk Behavior Web-Based Survey; SNS, social networking service; SSB, sugar-sweetened beverage.

TABLE 1 Participant characteristics according to duration of smartphone use[1]

Characteristics	Duration of smartphone use, min/d					
	1–59 ($n = 3553$)	60–119 ($n = 9626$)	120–179 ($n = 11,524$)	180–239 ($n = 9781$)	240–299 ($n = 5916$)	≥300 ($n = 14,201$)
Weighted *n*	173,643	476,850	570,108	482,329	283,049	670,059
Boys	2149 (60.8)	5896 (62.2)	6181 (54.8)	4628 (48.6)	2554 (44.2)	5520 (40.2)
School						
Middle school	1706 (45.2)	4860 (46.2)	5575 (44.1)	4763 (44.3)	2980 (45.8)	7079 (45.4)
High school	1847 (54.8)	4766 (53.8)	5949 (55.9)	5018 (55.7)	2936 (54.2)	7122 (54.6)
Region						
Rural	300 (6.9)	617 (5.3)	710 (4.8)	725 (5.7)	482 (6.5)	1353 (7.4)
Mid-sized	1582 (47.1)	4267 (46.5)	5467 (50.4)	4699 (51.2)	2875 (51.6)	7135 (53.7)
Metropolitan	1671 (46.0)	4742 (48.1)	5347 (44.9)	4357 (43.1)	2559 (42.0)	5713 (38.9)
Perceived household income						
Low	373 (9.9)	973 (10.1)	1392 (11.9)	1369 (13.8)	946 (15.9)	2734 (19.2)
Middle	1323 (36.4)	4068 (41.6)	5361 (46.3)	4743 (48.3)	2901 (48.8)	6901 (48.4)
High	1857 (53.7)	4585 (48.2)	4771 (41.8)	3669 (37.8)	2069 (35.3)	4566 (32.4)
Parental co-residence						
Both parents	3092 (88.0)	8355 (87.4)	9811 (85.9)	8140 (83.9)	4779 (81.6)	10785 (76.7)
1 parent	357 (9.4)	1073 (10.7)	1448 (12.1)	1412 (13.9)	984 (16.0)	2884 (19.8)
Others	104 (2.6)	198 (1.9)	265 (2.0)	229 (2.2)	153 (2.4)	532 (3.5)
Parents' highest education						
High school or lower	507 (14.0)	1803 (18.3)	2595 (22.4)	2631 (26.4)	1692 (28.2)	4627 (32.2)
College or higher	2703 (77.8)	6695 (71.2)	7465 (65.7)	5820 (60.8)	3344 (57.3)	6873 (49.8)
Unknown	343 (8.2)	1128 (10.5)	1464 (11.9)	1330 (12.9)	880 (14.4)	2701 (18.0)
Average weekly allowance, won						
<10,000	1366 (37.6)	3224 (32.4)	3365 (28.3)	2654 (26.1)	1610 (26.5)	3265 (22.2)
10,000 to <50,000	1750 (49.5)	5136 (53.7)	6561 (57.1)	5647 (57.9)	3356 (56.7)	8009 (56.2)
≥50,000	437 (13.0)	1266 (13.9)	1598 (14.5)	1480 (15.9)	950 (16.8)	2927 (21.6)
Academic performance						
Poor	627 (16.9)	2018 (20.6)	2856 (25.0)	2900 (30.2)	2075 (35.6)	6505 (46.8)
Average	830 (23.5)	2669 (28.1)	3482 (30.6)	3009 (31.0)	1785 (30.5)	3932 (27.4)
Good	1132 (32.4)	3048 (32.0)	3413 (29.3)	2680 (26.9)	1489 (24.7)	2675 (18.3)
Very good	964 (27.3)	1891 (19.3)	1773 (15.1)	1192 (11.8)	567 (9.2)	1089 (7.6)
Perceived stress						
Low	869 (24.1)	2343 (23.5)	2476 (21.0)	1856 (18.9)	1057 (17.6)	2286 (16.2)
Moderate	1464 (41.5)	4152 (43.6)	5151 (45.3)	4310 (43.9)	2468 (42.1)	5583 (39.6)
High	1220 (34.4)	3131 (32.9)	3897 (33.7)	3615 (37.1)	2391 (40.3)	6332 (44.1)
Self-rated health						
Poor or very poor	201 (5.6)	466 (5.0)	596 (5.2)	621 (6.6)	420 (7.5)	1218 (8.8)
Fair	617 (17.4)	1742 (18.5)	2279 (20.2)	2201 (22.8)	1396 (23.5)	3637 (25.9)
Good	1621 (45.7)	4305 (44.7)	5395 (46.7)	4474 (45.6)	2684 (45.4)	5958 (41.7)
Very good	1114 (31.3)	3113 (31.9)	3254 (27.9)	2485 (25.1)	1416 (23.6)	3388 (23.6)
Physical activity[2]						
None	532 (15.7)	1328 (14.3)	1764 (15.9)	1720 (18.1)	1076 (19.1)	2999 (21.5)
Moderate	1472 (42.4)	4073 (43.2)	5096 (44.7)	4317 (44.7)	2611 (44.6)	6034 (42.8)
High	1549 (41.8)	4225 (42.5)	4664 (39.5)	3744 (37.2)	2229 (36.4)	5168 (35.7)
Obese[3]	287 (8.5)	883 (9.2)	1080 (9.4)	968 (9.8)	617 (10.9)	1516 (11.0)
Smartphone addiction symptoms[4]						
Present	738 (21.6)	2736 (29.5)	4323 (38.8)	3988 (42.1)	2591 (45.3)	6260 (45.2)
Absent	2815 (78.4)	6890 (70.5)	7201 (61.2)	5793 (57.9)	3325 (54.7)	7941 (54.8)
Most frequently used smartphone content type						
Education/information search	725 (21.6)	1263 (13.7)	888 (8.2)	571 (6.2)	283 (5.0)	472 (3.6)
Messenger/e-mail	736 (20.7)	2382 (25.0)	3079 (27.0)	2672 (27.8)	1597 (26.7)	4509 (31.9)
SNS/forum	374 (10.3)	1296 (13.3)	2045 (17.3)	2028 (20.2)	1340 (22.6)	3681 (25.6)
Game	573 (15.2)	1511 (15.2)	1657 (13.9)	1250 (12.6)	729 (11.8)	1561 (10.8)
Movie/video/music	693 (19.6)	2104 (21.9)	2656 (23.3)	2286 (23.4)	1389 (24.2)	2717 (19.3)
Webtoon/Web-novel	371 (10.4)	989 (10.3)	1102 (9.5)	888 (8.9)	528 (8.9)	1036 (7.3)
Shopping/others	81 (2.1)	81 (0.7)	97 (0.8)	86 (0.9)	50 (0.8)	225 (1.5)

(*Continued*)

TABLE 1 (*Continued*)

	Duration of smartphone use, min/d					
Characteristics	1–59 ($n = 3553$)	60–119 ($n = 9626$)	120–179 ($n = 11{,}524$)	180–239 ($n = 9781$)	240–299 ($n = 5916$)	≥300 ($n = 14{,}201$)

[1]Values are *n* (weighted %) unless otherwise indicated. Weighted *n* reflects weighted counts and refers to the entire Korean adolescent population in 2017.
[2]High level of physical activity was defined as engaging in ≥20 min vigorous-intensity physical activity for >3 d/wk or ≥60 min moderate-intensity physical activity for >5 d/wk during the past 7 d. Moderate level of physical activity was defined as engaging in some physical activity while not meeting the criteria for high level.
[3]Obesity was defined as BMI-for-age ≥95th percentile based on the 2017 Korean National Growth Chart (39).
[4]Presence of smartphone addiction symptoms was defined as responding "yes" to any of the following 3 questions: "Have you ever experienced serious conflicts with family members due to smartphone use?" "Have you ever experienced serious conflicts with friends or peers due to smartphone use?" "Have you ever experienced difficulties doing schoolwork due to smartphone use?"

was slightly longer among participants who used smartphones mainly for SNS/forum than for other content types. Table 1 presents characteristics of study participants according to the duration of smartphone use. Prolonged smartphone users (≥300 compared with 1–59 min/d) were more likely to be girls, obese, and have lower perceived household income, lower parental education, higher average weekly allowance, poor academic performance, higher perceived stress, poor self-rated heath, lower levels of physical activity, and presence of smartphone addiction symptoms. They were also less likely to be living in metropolitan cities and living with both parents. **Supplemental Table 2** presents characteristics of study participants according to content type of smartphone use. Adolescents using smartphones most frequently for education/information search, compared with other content types, were more likely to be in high school, living with both parents, and have higher parental education and good academic performance, and were less likely to have smartphone addiction symptoms.

Duration of smartphone use

Table 2 shows the associations of smartphone usage duration with prevalence of dietary risk factors. Prolonged smartphone use (≥300 compared with 1–59 min/d) was statistically significantly associated with higher prevalence of all dietary risk factors except frequent intake of chips/crackers (frequent breakfast skipping: OR: 1.60; 95% CI: 1.45, 1.76; less frequent intakes of fruits: OR: 1.44; 95% CI: 1.30, 1.59; and vegetables: OR: 1.32; 95% CI: 1.18, 1.47; more frequent intakes of instant noodles: OR: 1.65; 95% CI: 1.47, 1.84; fast food: OR: 1.36; 95% CI: 1.20, 1.53; and SSBs: OR: 1.92; 95% CI: 1.75, 2.11; all P-trend < 0.001), adjusting for the most frequently used content type. For most dietary risk factors, the associations became statistically significant at >120 min/d of smartphone use. Most associations remained statistically significant after Bonferroni correction for multiple testing.

Content type of smartphone use

Table 3 presents the associations of the single most frequently used smartphone content type with prevalence of dietary risk factors, adjusting for total duration of smartphone use. Compared with using smartphones most frequently for education/information search, using smartphones for messenger/e-mail, SNS/forum, and games were associated with less frequent intakes of fruits (OR: 1.21; 95% CI: 1.12, 1.31; OR: 1.28; 95% CI: 1.17, 1.40; and OR: 1.20; 95% CI: 1.10, 1.32, respectively) and vegetables (OR: 1.24; 95% CI: 1.12, 1.37; OR: 1.26; 95% CI: 1.13, 1.40; and OR: 1.25; 95% CI: 1.12, 1.40, respectively). Using smartphones most frequently for messenger/e-mail and SNS/forum were also positively associated with frequent intake of SSBs (OR: 1.24; 95% CI: 1.14, 1.35 and OR: 1.18; 95% CI: 1.08, 1.29; respectively). Most associations remained statistically significant after Bonferroni correction for multiple testing.

For most dietary risk factors, similar patterns of associations were observed with both weekday and weekend smartphone use (**Supplemental Table 3**), among both obese and nonobese adolescents (**Supplemental Tables 4** and **5**), and among both adolescents with and without smartphone addiction symptoms (**Supplemental Tables 6** and **7**). When we stratified by sex, school, perceived household income, parents' education, region, and perceived stress, the direction of association was largely consistent among all subgroups (**Supplemental Table 8**).

Discussion

In a nationally representative sample of Korean adolescents, we observed that prolonged smartphone use was associated with unhealthful dietary intakes (frequent breakfast skipping; less frequent intakes of fruits and vegetables; more frequent intakes of instant noodles, fast food, and SSBs). With adjustment for usage duration, adolescents who used their smartphones most frequently for messenger/e-mail and SNS/forum were associated with less frequent intakes of fruits and vegetables and more frequent intake of SSBs. Most associations were similar between obese and nonobese adolescents and between those with and without smartphone addiction symptoms. Our data suggest that both duration and content type of smartphone use are independently associated with dietary risk factors among adolescents.

Our findings of positive associations between prolonged smartphone use and dietary risk factors are consistent with those from previous studies of smartphone addiction (18, 40). In previous studies, adolescents with addictive smartphone use were more likely to have dysregulated eating (18), food addiction (18), meal skipping (40), and low intakes of fruits and vegetables (40). Whereas earlier studies (18–21, 40) primarily focused on smartphone addiction, the present study examined a wider range of usage duration. Among both adolescents with and without smartphone addiction symptoms, we observed associations between smartphone usage duration and dietary risk factors with statistically significant linear trends, suggesting that even the moderate use of smartphone without addiction symptoms may independently influence diet. These associations also persisted after adjustment for content types of smartphone use, further supporting the independent associations of usage duration. Our results were also consistent in various stratified analyses, suggesting that adolescents of all subgroups may be susceptible to the negative effects of prolonged smartphone use. These findings are in line with earlier studies of TV watching (3–7, 41–44) and combined screen time (4, 5, 7, 42, 44). Because most television contents are now easily accessible on smartphone screens, adolescents may be exposed to similar

TABLE 2 Multivariable ORs and 95% CIs for the associations of smartphone usage duration with prevalence of dietary risk factors among 54,601 adolescents in the Korea Youth Risk Behavior Web-Based Survey 2017[1]

Dietary risk factors[3]	Duration of smartphone use,[2] min/d 1–59 ($n = 3553$)	60–119 ($n = 9626$)	120–179 ($n = 11,524$)	180–239 ($n = 9781$)	240–299 ($n = 5916$)	≥300 ($n = 14,201$)	P-trend[4]
Frequent breakfast skipping	1.00 (ref.)	1.07 (0.97, 1.18)	1.19 (1.08, 1.31)[5]	1.30 (1.18, 1.44)[5]	1.36 (1.22, 1.51)[5]	1.60 (1.45, 1.76)[5]	<0.001[5]
Less frequent intake of fruits	1.00 (ref.)	1.05 (0.96, 1.15)	1.14 (1.03, 1.25)	1.28 (1.16, 1.41)[5]	1.39 (1.25, 1.55)[5]	1.44 (1.30, 1.59)[5]	<0.001[5]
Less frequent intake of vegetables	1.00 (ref.)	1.22 (1.11, 1.35)[5]	1.35 (1.23, 1.49)[5]	1.55 (1.40, 1.72)[5]	1.32 (1.17, 1.49)[5]	1.32 (1.18, 1.47)[5]	<0.001[5]
Frequent intake of instant noodles	1.00 (ref.)	1.16 (1.04, 1.30)	1.26 (1.12, 1.40)[5]	1.45 (1.29, 1.63)[5]	1.53 (1.35, 1.72)[5]	1.65 (1.47, 1.84)[5]	<0.001[5]
Frequent intake of fast food	1.00 (ref.)	1.03 (0.91, 1.16)	1.09 (0.97, 1.23)	1.28 (1.14, 1.44)[5]	1.30 (1.14, 1.47)[5]	1.36 (1.20, 1.53)[5]	<0.001[5]
Frequent intake of chips/crackers	1.00 (ref.)	0.91 (0.84, 0.99)	0.99 (0.91, 1.08)	0.99 (0.90, 1.08)	1.03 (0.93, 1.13)	1.05 (0.96, 1.14)	0.001[5]
Frequent intake of SSBs	1.00 (ref.)	1.09 (0.99, 1.20)	1.31 (1.20, 1.43)[5]	1.45 (1.32, 1.60)[5]	1.58 (1.43, 1.74)[5]	1.92 (1.75, 2.11)[5]	<0.001[5]

[1]Values are ORs (95% CIs) unless otherwise indicated. SSB, sugar-sweetened beverage.

[2]All models were adjusted for sex (boy, girl), grade in school (7–12, continuous), region (rural, mid-sized, metropolitan), perceived household income level (low, middle, high), parental co-residence (both parents, 1 parent, others), parents' highest education (high school or lower, college or higher, unknown), average weekly allowance (<10,000, 10,000–49,990, ≥50,000 won), perceived stress (low, moderate, high), self-rated health (poor or very poor, fair, good, very good), physical activity (none, moderate, high), academic performance (poor, average, good, very good), smartphone addiction symptoms (present, absent), and content type of smartphone use (education/information search, messenger/e-mail, SNS/forum, game, movie/video/music, Webtoon/Web-novel, shopping/others), as well as mutually adjusting for all dietary risk factors under study.

[3]Each dietary variable was converted into a binary dietary risk factor (frequent breakfast skipping: ≥5 times/wk; less frequent intake of fruits: <7 times/wk; less frequent intake of vegetables: <3 times/d; more frequent intakes of instant noodles, fast food, and chips/crackers: ≥3 times/wk; and more frequent intake of SSBs: ≥1 time/d).

[4]P-trend was estimated using the Wald test for smartphone usage duration as a continuous variable (1–6, ordinal score).

[5]Nominal statistical significance at a Bonferroni-corrected α level of 0.00714 (7 tests/exposure).

contents while using smartphones. Similarly to prolonged TV viewers, prolonged smartphone users are more likely to be exposed to food advertisements and marketing contents (45) that encourage obesogenic diet because the food products that are most frequently advertised are energy-dense, nutrient-poor foods such as fast food and SSBs (46–49). Studies have shown that frequent exposures to advertisements of energy-dense, nutrient-poor foods are associated with higher prevalence of overweight (50). On digital platforms, some advertisements are also disguised within various digital media contents, including games, videos, and blogs shared by friends and social media influencers, promoting indiscriminate exposures to unhealthy food marketing. Further, the visual exposures to photos and videos of foods and diet-related contents from digital platforms may influence adolescents' food choices and consumption. Prolonged smartphone use may also provide increased opportunities for snacking, leading to overconsumption of finger foods, fast food, and easy-to-cook foods (e.g., instant noodles), as shown in our study. Eating in front of a screen may also promote "mindless eating" (eating without being fully aware of the quantity and quality of the foods), leading to consumption of extra calories (51, 52) and weight gain. Lastly, sleep deprivation and poor sleep quality are often found among adolescents with prolonged smartphone use (4, 53–56). Compared with fixed screens such as TV and desktop computers, smartphones are likely to have a much stronger impact on sleep quality because the portability of smartphones allows them to be easily brought into the bedroom (57) and used before bedtime. Using smartphones before bedtime is associated with late sleep onset (58) and poor sleep quality (54, 58), partially due to delayed production of melatonin, the hormone that regulates the sleep-wake cycle (59, 60). Poor sleep may increase appetite and influence food consumption by altering concentrations of appetite-regulating hormones (ghrelin and leptin). Prolonged smartphone use is also associated with increased sedentary time (e.g., using smartphones in a sitting or lying position) and decreased levels of physical activity (61–64), further contributing to uncontrolled appetite, poor metabolism, and heightened cravings for savory foods (65, 66). **Supplemental Figure 2** presents a conceptual framework outlining possible mechanisms that may link smartphone use and unhealthful diet.

Our data also suggest that the effects of smartphone use on diet may vary depending on the contents that adolescents are exposed to while using smartphones. In the present study, adolescents who used smartphones most frequently for non-educational (as opposed to educational) contents, such as messenger, SNS/forum, and games, had less frequent intakes of fruits and vegetables, adjusting for total duration of smartphone use. Similarly, a previous study showed that prolonged leisure-time but not study-time Internet use was associated with less frequent intakes of fruits and vegetables (67), suggesting that the associations may be partially due to the contents that adolescents commonly access during their leisure time but not during study time. Because marketing companies also utilize non-educational platforms (e.g., SNS) more often than educational platforms, adolescents are likely to have more frequent exposures to food advertisements while playing games and reading SNSs/forums. Further, whereas educational contents may provide more accurate, useful information on health and nutrition, adolescents are more likely to obtain false or misleading information from non-educational contents, triggering unhealthy behaviors. Further studies are needed to investigate ways to minimize the negative effects of smartphone use on dietary behaviors in adolescents.

TABLE 3 Multivariable ORs and 95% CIs for the associations of most frequently used smartphone content type with prevalence of dietary risk factors among 54,601 adolescents in the Korea Youth Risk Behavior Web-Based Survey 2017[1]

	Most frequently used smartphone content type[2]							
Dietary risk factors[3]	Education/information search ($n = 4202$)	Messenger/e-mail ($n = 14{,}975$)	SNS/forum ($n = 10{,}764$)	Game ($n = 7281$)	Movie/video/music ($n = 11{,}845$)	Webtoon/Web-novel ($n = 4914$)	Shopping/others ($n = 620$)	*P*-diff[4]
Frequent breakfast skipping	1.00 (ref.)	1.13 (1.05, 1.22)[5]	1.05 (0.97, 1.14)	0.95 (0.87, 1.04)	1.04 (0.96, 1.12)	0.90 (0.82, 0.99)	1.09 (0.91, 1.31)	<0.001[5]
Less frequent intake of fruits	1.00 (ref.)	1.21 (1.12, 1.31)[5]	1.28 (1.17, 1.40)[5]	1.20 (1.10, 1.32)[5]	1.17 (1.08, 1.26)[5]	1.10 (1.00, 1.21)	1.08 (0.87, 1.35)	<0.001[5]
Less frequent intake of vegetables	1.00 (ref.)	1.24 (1.12, 1.37)[5]	1.26 (1.13, 1.40)[5]	1.25 (1.12, 1.40)[5]	1.12 (1.01, 1.24)	1.23 (1.09, 1.39)[5]	0.79 (0.62, 1.02)	<0.001[5]
Frequent intake of instant noodles	1.00 (ref.)	1.05 (0.96, 1.15)	1.02 (0.93, 1.12)	1.09 (0.99, 1.20)	0.99 (0.91, 1.09)	1.04 (0.93, 1.16)	0.96 (0.77, 1.19)	0.19
Frequent intake of fast food	1.00 (ref.)	1.13 (1.02, 1.24)	1.06 (0.96, 1.17)	0.96 (0.86, 1.07)	1.01 (0.91, 1.11)	1.06 (0.94, 1.19)	1.01 (0.80, 1.28)	0.01
Frequent intake of chips/crackers	1.00 (ref.)	0.89 (0.82, 0.96)[5]	0.94 (0.86, 1.02)	1.11 (1.02, 1.21)	0.91 (0.84, 0.99)	0.98 (0.90, 1.08)	0.85 (0.69, 1.03)	<0.001[5]
Frequent intake of SSBs	1.00 (ref.)	1.24 (1.14, 1.35)[5]	1.18 (1.08, 1.29)[5]	1.06 (0.97, 1.16)	1.11 (1.02, 1.21)	1.06 (0.96, 1.18)	1.12 (0.91, 1.37)	<0.001[5]

[1] Values are ORs (95% CIs) unless otherwise indicated. SNS, social networking service; SSB, sugar-sweetened beverage.
[2] All models were adjusted for sex (boy, girl), grade in school (7–12, continuous), region (rural, mid-sized, metropolitan), perceived household income level (low, middle, high), parental co-residence (both parents, 1 parent, others), parents' highest education (high school or lower, college or higher, unknown), average weekly allowance (<10,000, 10,000–49,990, ≥50,000 won), perceived stress (low, moderate, high), self-rated health (poor or very poor, fair, good, very good), physical activity (none, moderate, high), academic performance (poor, average, good, very good), smartphone addiction symptoms (present, absent), and smartphone usage duration (h/d, continuous), as well as mutually adjusting for all dietary risk factors under study.
[3] Each dietary variable was converted into a binary dietary risk factor (frequent breakfast skipping: ≥5 times/wk; less frequent intake of fruits: <7 times/wk; less frequent intake of vegetables: <3 times/d; more frequent intakes of instant noodles, fast food, and chips/crackers: ≥3 times/wk; and more frequent intake of SSBs: ≥1 time/d).
[4] *P*-diff estimated using the global *F* test for smartphone content type categories.
[5] Nominal statistical significance at a Bonferroni-corrected α level of 0.00714 (7 tests/exposure).

We acknowledge that this study has limitations. Given the cross-sectional design of the study, it is difficult to clarify the temporal relation and thus it should not be interpreted as causal. Further studies are needed to confirm the relation using a longitudinal study design. In our content type analysis, we used data on the single most frequently used smartphone content type. If participants used multiple contents at the same time, the associations that we observed in the study may reflect mixed effects of multiple content types. Our data also lack information on the time of day (e.g., day compared with night) and environmental settings (e.g., home compared with outdoor) of smartphone use, and thus further studies are needed to clarify the relations accounting for various factors that may influence food options and appetite. Our data also lack information on the time spent using other screen devices such as TV and computers and thus we were not able to adjust for them in our analyses. If smartphone usage patterns are correlated with other screen device use, it is possible that our results are not independent of other screen time. Further, the exposure and outcome data were self-reported and thus are subject to measurement errors. Lastly, we performed multiple testing. However, most of our results remained statistically significant after the Bonferroni correction for multiple testing.

Despite the limitations, this study has important strengths. We used nationally representative data and thereby increased the generalizability of our study findings. However, our results may not be generalizable to adolescents of other countries if their dietary environment and food availability are substantially different from those of Korea. We also reduced confounding by carefully adjusting for potential confounders such as demographic, lifestyle, and dietary variables. Using a large sample size, we were also able to perform multiple stratified analyses with sufficient statistical power.

In summary, we observed that both smartphone usage duration and content type were independently associated with unhealthful dietary intakes among adolescents. Given the intensified use of smartphones in adolescents, more efforts should be taken to provide appropriate guidance for developing healthful smartphone usage behaviors and to introduce restrictions on unhealthy food marketing that targets young children and adolescents in digital space. Public health strategies should also focus on making accurate information on health and nutrition available and more easily accessible on digital platforms. Further, more studies should investigate the possible positive and negative effects of smartphone use on adolescent health.

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Data Availability

Data described in the article are publicly and freely available without restriction at the Korea Disease Control and Prevention Agency repository (http://www.kdca.go.kr/yhs).

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