Did the increase in sitting time due to COVID-19 lead to over-weight or obesity in adolescents? A study based on the Korea Youth Risk Behavior Web-based Survey (KYRBWS) 2018-2021

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Abstract

Introduction: This study aimed to estimate the association between obesity and sitting hours in Korean adolescents with obesity during the coronavirus disease 2019 (COVID-19) pandemic. Since adolescent with obesity is closely linked with the incidence of cardiovascular disease, it is important to identify the factors that increase the prevalence of adolescent with obesity and prevent it early.

Methods: We used the Korean Youth Risk Behavior Web-based Survey (KYRBWS) data. The primary outcome variables were changes in obesity status during and after the COVID-19 pandemic. Multiple logistic regression analysis was performed to examine the association between increased sitting hours for purposes other than study and obesity status.

Results: The prevalence of obesity was significantly higher during the COVID-19 pan-demic than before the COVID-19 pandemic (odds ratio [OR], 1.186, 95% confidence interval [CI]:1.148–1.226). There was a significant increase in the OR for sitting hours per week for purposes other than study (OR, 1.02, 95% CI, 1.018–1.023). Compared to low household income students, the OR decreased for middle- (OR = 0.801, 95% CI:0.796, 0.871) and high-income household students (OR, 0.832, 95% CI: 0.796–0.871).

Discussion/Conclusion: The results of this study confirmed the relationship between sit-ting hours and obesity in adolescents during the pandemic. To prevent or avoid adolescent with obesity, further studies are needed to understand whether the increase in obesity rates during the pandemic is a temporary trend.

Introduction

Obesity among children and adolescents has increased steadily and is emerging as a serious social problem [1–2]. Obese children and adolescents are approximately five times more likely to be obese in adulthood than those who are not obese, and approximately 80% of obese adolescents will remain obese in adulthood [3]. Since previous studies have showed that childhood obesity has associated with the incidence of cardiovascular disease risk factors [4–9], it is important to identify and prevent factors that increase the prevalence of obese.

The coronavirus disease 2019 (COVID-19) pandemic has become the biggest public health challenge since the Middle East respiratory disease (MERS) outbreak in 2015, posing a challenge to workplace safety and health in Korea [10]. To prevent the early spread of COVID-19, the government implemented social distancing policies at four levels, including working from home, closing schools, starting online classes, limiting the number of people in private gatherings, reducing business hours, restricting large-scale indoor activities, and restricting the use of sports facilities, such as water parks [11–12].

It is assumed that the lifestyle of adolescents has naturally changed, as these policies restrict people's daily lives. In particular, physical activity has decreased due to social distancing, school closures, and home isolation due to the risk of COVID-19 infection, which is expected to negatively affect weight

control. This is thought to lead to an increase in the prevalence of obesity in adolescents as active behavior decreases.

This study aimed to analyze the prevalence of obesity changes caused by changes in sitting time during the pandemic period and to suggest policies for appropriate preventive measures due to the prolonged pandemic period.

Materials And Methods

Study design

This study used the Korea Youth Risk Behavior Web-Based Survey (KYRBWS) from the Korea Center for Disease Control and Prevention to estimate national representative values and extrapolate the findings to the entire Korean population.

On January 20, 2020, the first confirmed case of COVID-19 in Korea was reported [13]. This study compared the prevalence of obesity among the 2018–2019 participants (the before COVID-19 pandemic group) with the 2020–2021 participants (the during COVID-19 pandemic group).

The primary outcome was the difference in obesity prevalence due to increased sitting hours per week for purposes other than study before and during COVID-19. Subgroup analyses on obesity status were conducted according to biological sex, school grade, average sleep hours per week, whether to skip breakfast more than five days a week, smoking status, household income, academic level, region, and sitting hours per week for purposes other than study.

Data and study population

This study analyzed cross-sectional data from the KYRBWS, a survey of middle- and high-school students, to understand the current status and trends of health behaviors, such as smoking, drinking, physical activity, diet, mental health, awareness of damage and safety, and oral health of Korean adolescents. This survey is a government-approved statistical survey (approval number: 11758) and has been conducted annually since 2005. A sample of middle- and high-school students representing the whole country was obtained using stratified multi-stage sampling, and students were surveyed anonymously during regular class time based on a self-filling web [14].

Our study population consisted of adolescents (n =227,139) aged 12–18 years from the KYRBWS 2018 to 2021. We excluded adolescents with missing monthly age, height, and weight information. The final sample comprised 226,324 adolescents.

Sitting time was added to the following questions: sitting time per week for purposes other than study. This includes watching TV, playing games, using the Internet, chatting, and sitting on a move. Obesity was assessed by measuring the BMI. It is one of the most widely used and recommended methods for determining the obesity status of children and adolescents [15]. BMI was calculated by dividing the body

weight in kilograms by the body height in meter square. Age- and sex-adjusted BMI Z scores were obtained using a Korean National Growth Chart [16]. Adolescents were considered obese if their BMI was in the 95th percentile, and overweight was defined as follows: 85th percentile ≤ BMI < 95th percentile for age and sex.

Statistical analysis

The outcome variable of this study was the effect of changes in sitting time before and after the pandemic on adolescents with obesity behavior. Categorical and continuous variables were compared between the groups using the chi-squared test and t-test. Multiple logistic regression analysis was performed to examine the association and interaction between the prevalence of obesity and levels of demographic and lifestyle factors, including sitting hours per week for purposes other than study, with adjustment for covariates. We also estimated the odds ratio (OR) and 95% confidence interval (CI) of the OR. Responses that had logical errors and those that were outliers were processed as missing values, and observations with missing data were excluded from the analysis. All analyses were carried out using the survey procedures provided in SAS software 9.4. Statistical significance was set at $P < 0.05$. Because the KYRBWS data included multi-level sampling, layering, and clustering, we analyzed it by applying weights. Responses with logical errors or outliers were processed as missing values.

Results

General information on study observation

Table 1 presents the participants' general characteristics. Participants comprised of 226,324 adolescents with an average age of 15.16 years, with 51.85% females and 48.15% males. Among the middle and high school students who participated in the survey, 16.32%, 16.26%, and 16.15% were in the 7th, 8th, and 9th grades, respectively, and they were classified as 'middle school students' in Korea. In addition, 16.40%, 16.98%, and 17.88% of students were in the 10th, 11th, and 12th grades, respectively, and were classified as 'high school students' in Korea. Approximately 95.42% of the students lived in metropolitan or city areas, and only 4.58% lived in rural areas. Household income level, academic level, smoking status, and region were used as variables.

Table 1
General Information of Study Observation

		Before COVID-19		During COVID-19		Total		P value*
		Percent	SE	Percent	SE	Percent	SE	
Total (N)		116,803		109,521		226,324		
Age (mean, SE)		(15.12 ± 0.02)		(15.21 ± 0.02)		(15.16 ± 0.01)		0.0001
Sex	Male	51.95	0.87	51.74	0.80	51.85	0.59	0.8685
	Female	48.05	0.87	48.26	0.80	48.15	0.59	
School grade	7th grade	15.25	0.19	17.43	0.20	16.32	0.14	< .0001
	8th grade	15.53	0.19	17.03	0.19	16.26	0.13	
	9th grade	16.41	0.19	15.89	0.18	16.15	0.13	
	10th grade	16.53	0.18	16.26	0.19	16.40	0.13	
	11st grade	17.13	0.19	16.83	0.19	16.98	0.14	
	12nd grade	19.14	0.22	16.56	0.20	17.88	0.15	
School type	Mixed-sex school	65.33	1.13	68.05	1.08	66.66	0.78	0.3066
	Boys-only school	17.54	0.97	15.93	0.90	16.76	0.66	
	Girls-only school	17.13	0.96	16.01	0.92	16.58	0.67	
Academic level	High	13.11	0.13	12.41	0.14	12.77	0.09	< .0001
	Upper middle	25.22	0.14	24.57	0.15	24.90	0.10	
	Middle	29.82	0.14	30.59	0.15	30.19	0.10	
	Lower middle	22.08	0.14	22.51	0.15	22.29	0.11	
	Low	9.78	0.10	9.92	0.11	9.85	0.08	
Region	Metropolitan	50.85	0.52	50.18	0.52	50.52	0.37	0.5861
	City area	44.50	0.54	45.33	0.53	44.90	0.38	
	Rural	4.65	0.27	4.49	0.21	4.58	0.17	

		Before COVID-19		During COVID-19		Total		P value*
		Percent	SE	Percent	SE	Percent	SE	
Smoking status	None / month	93.46	0.14	95.61	0.10	94.51	0.09	< .0001
	More than 1 / month	6.54	0.14	4.39	0.10	5.49	0.09	
Skipping breakfast	0–4 days / week	65.42	0.20	62.36	0.21	63.93	0.14	< .0001
	5–7 days / week	34.58	0.20	37.64	0.21	36.07	0.14	
Average sleep hour per week (mean, SE)		(6.27 ± 0.01)		(6.19 ± 0.01)		(6.23 ± 0.01)		< .0001
Household income	High	10.97	0.13	11.02	0.15	10.99	0.10	< .0001
	Upper middle	29.26	0.19	28.98	0.21	29.13	0.14	
	Middle	46.98	0.20	48.29	0.23	47.61	0.15	
	Lower middle	10.57	0.12	9.67	0.12	10.14	0.08	
	Low	2.22	0.05	2.04	0.05	2.13	0.03	

* Categorical variables were analyzed using the χ^2 test; continuing variables were analyzed using the t-test.

Trend of adolescents' prevalence of obesity and overweight or obesity with sitting time

Figure 1 shows the prevalence of obesity and overweight or obesity with sitting hours per week for purposes other than study. Compared to before COVID-19, the prevalence of obesity and sitting hours per week for purposes other than study in-creased significantly during the COVID-19 pandemic. Compared to before the COVID-19 pandemic, the prevalence of overweight or obesity and sitting hours per week for purposes other than study increased significantly during the COVID-19 pan-demic. In particular, the prevalence of obesity and overweight or obesity increased in 2020, the year of the COVID-19 pandemic, compared to 2019, before the COVID-19 pandemic.

Comparison of adolescents with obesity before and during COVID-19

Table 2 presents a comparison of adolescents with obesity before and during the COVID-19 pandemic. In both males (13.56→16.56, P < .0001) and females (8.09→8.75, P = 0.003), the prevalence of obesity increased during the COVID-19 pandemic. The prevalence of obesity by region increased significantly during the COVID-19 pandemic in metropolitan (10.59→12.54, P < .0001) and city (11.05→12.91, P < .0001) areas, but the increase in the prevalence of obesity among students living in rural was not statistically significant.

Table 2
Comparison of adolescents with obesity before and during COVID-19

			Before COVID-19		During COVID-19		
			Percent	Std Err	Percent	Std Err	P value[a]
Total		**None**	89.07	0.12	87.20	0.14	< .0001
		Obesity	10.93	0.12	12.80	0.14	
Sex	**Male**	**None**	86.44	0.16	83.44	0.19	< .0001
		Obesity	13.56	0.16	16.56	0.19	
	Female	**None**	91.91	0.15	91.25	0.15	0.003
		Obesity	8.09	0.15	8.75	0.15	
Region	**Metropolitan**	**None**	89.41	0.16	87.46	0.20	< .0001
		Obesity	10.59	0.16	12.54	0.20	
	City area	**None**	88.95	0.20	87.09	0.21	< .0001
		Obesity	11.05	0.20	12.91	0.21	
	Rural	**None**	86.33	0.51	85.26	0.57	0.1968
		Obesity	13.67	0.51	14.74	0.57	

[a] variables were analyzed using the χ2 test

Comparison of adolescents' sitting time before and during COVID-19

Table 3 presents a comparison of adolescents' sitting hours per week for purposes other than study before and during the COVID-19 pandemic. Sitting hours per week for purposes other than study increased significantly from 7.63 h per week to 8.96 h per week during the COVID-19 pandemic. Sitting time increased significantly in all subgroups by sex (7.60→9.01, P < .0001 [male]; 7.66→8.90, P < .0001 [female]) and region (7.49→8.73, P < .0001 [metropolitan]; 7.76→9.16, P < .0001 [city area]; 7.88→9.54, P < .0001 [rural]).

Table 3

Comparison of adolescents' sitting hour per week for purposes other than study before and during COVID-19

		Before COVID-19		During COVID-19		P value[a]
		Mean	Std Err of Mean	Mean	Std Err of Mean	
Total		7.63	0.02	8.96	0.03	< .0001
Sex	**Male**	7.60	0.03	9.01	0.04	< .0001
	Female	7.66	0.03	8.90	0.04	< .0001
Region	**Metropolitan**	7.49	0.03	8.73	0.03	< .0001
	City area	7.76	0.04	9.16	0.04	< .0001
	Rural	7.88	0.09	9.54	0.11	< .0001

[a] variables were analyzed using the $\chi 2$ test

Association between obesity before and during COVID-19

The estimated OR (with 95% CI) for obesity prevalence is shown in Table 4. A multiple logistic regression analysis model was used to examine the relationship be-tween the likelihood of obesity and factors. The prevalence of obesity was significantly higher during the COVID-19 pandemic than before the COVID-19 pandemic (OR, 1.186; 95% CI: 1.148–1.226), even after adjusting for covariates.

Table 4
Obesity multiple logistic regression

		OR	(95% CI)		P value[a]
Sex	**Male**	1 [Reference]			< .0001
	Female	0.503	0.487	0.52	
Grade	**7th grade**	1 [Reference]			< .0001
	8th grade	0.965	0.916	1.017	
	9th grade	1.042	0.986	1.102	
	10th grade	1.191	1.123	1.262	
	11st grade	1.283	1.211	1.359	
	12nd grade	1.433	1.352	1.519	
Covid	**Before Covid**	1 [Reference]			< .0001
	During Covid	1.186	1.148	1.226	
Average sleep hour per week		0.982	0.97	0.994	0.0025
Skipping breakfast more than 5 days a week	**0–4 / week**	1 [Reference]			0.0415
	5–7 / week	1.032	1.001	1.063	
Smoking status	**None / month**	1 [Reference]			< .0001
	More than 1 / month	0.807	0.756	0.861	
Household income	**High**	0.832	0.796	0.871	< .0001
	Middle	0.801	0.768	0.837	
	Low	1 [Reference]			
Sitting hour per week for purposes other than study		1.02	1.018	1.023	< .0001
Academic level	**High**	0.615	0.577	0.656	< .0001
	Upper middle	0.707	0.669	0.748	
	Middle	0.787	0.747	0.83	

		OR	(95% CI)		P value[a]
	Lower middle	0.934	0.887	0.984	
	Low	1 [Reference]			
Region	**Metropolitan**	0.78	0.732	0.832	< .0001
	City area	0.798	0.747	0.852	
	Rural	1 [Reference]			
Abbreviations : OR, odds ratio					
[a] Calculated using multiple logistic regression analysis.					

There was a significant increase in the OR for sitting hours per week for purposes other than study (OR, 1.02; 95% CI, 1.018–1.023). Compared to low-income household students, the OR decreased for middle- (OR, 0.801; 95% CI, 0.796–0.871) and high-income household students (OR, 0.832; 95% CI: 0.796–0.871).

Discussion

According to the results of this study, during the COVID-19 period, the sitting time of Korean adolescents significantly increased, and the prevalence of obesity in-creased. This obesity prevalence demonstrated a tendency to increase in statistically significant manner after the pandemic, even when the effects of demographic covariates, such as sex, grade, and region, were analyzed using multivariate logistic regression. Similar trends were observed in the overweight analysis (Supplementary Materials).

To the best of our knowledge, this is the first study in Korea that addresses the changes in obesity rates by measuring the amount of physical activity during sitting time before and after the COVID-19 pandemic. Previous studies in Korea have demonstrated that the longer the sitting time for purposes other than the study, the higher the prevalence of obesity [17]. Another study in Korea showed that adolescents' high weight tends to be associated with a low frequency of physical education classes, and adolescents who sit for more than two hours a day are more likely to be obese [18–19]. The finding that a decrease in physical activity due to increased sitting time increases obesity in adolescents is consistent with the results of our study.

Previous studies before the COVID-19 pandemic have shown that adolescents gain weight during summer vacation, suggesting that they have decreased physical activity, increased sitting behavior, increased access to harmful snacks, no plans, de-creased self-monitoring, and irregular sleep patterns. [20–22]. The lockdown period of COVID-19 can be considered as a type of vacation, and previous studies considered the lockdown period as an early summer vacation, suggesting that the child with obesity rate increases in proportion to the number of months of closure, resulting in rapid increase of new obesity

cases [23–24]. In addition to school closures, there were restrictions on the large gatherings and business hours in public places and restaurants during the pandemic, which are believed to have created an environment that increased the obesity rate by limiting teenagers' physical activities. As classes were switched non-face-to-face due to Covid-19, the screen time of adolescents increased, which further exacerbated their sitting habits [25–26]. According to the "2021 adolescent Statis-tics" released by the Korea National Statistical Office, the average internet time of adolescents increased by 10 to 27.6 h in 2020 compared to 17.6 h in 2019 [27].

The negative relationship between a family's financial status and obesity prevalence in adolescents has been steadily reported in the past [28–29]. This study also con-firmed that the obesity prevalence in adolescents in the group with low-income household was higher than that in the group with high-income household. As the economy became more difficult due to COVID-19, many people lost their jobs, or their incomes decreased [30]. Therefore, it can be inferred that the prevalence of obesity in adolescents increased because of the increase in households whose family financial status deteriorated during the pandemic.

This study is meaningful in that it analyzes several variables, such as gender, grade, and housing income, including adolescents' sitting time, and investigates whether each variable affects the increase in the prevalence of overweight or obesity among adolescents during Covid-19. However, there are some limitations to the use of secondary data. First, memory bias may have existed because the data used in the study relied on the memory of the respondents and not observational data. Second, as the number of participants in the survey changed every year, it was not possible to confirm the change in individual students before and after the pandemic.

Conclusion

The prevalence of obesity among teenagers in Korea increased during the COVID-19 pandemic. Therefore, a policy is needed to provide adolescents living in a low-income household with programs to practice a healthy life at home. Further studies are needed to determine whether the increased obesity rate during the pandemic is a temporary trend and to provide obesity preventing strategies based on various fac-tors for adolescents by maintaining healthy lifestyles.

Declarations

- **Ethics approval and consent to participate**

The KYRBWS was reviewed by the Korea Centers for Disease Control and Prevention's Institutional Bioethics Committee with government-approved statistics (Approval No. 11758) based on the National Health Promotion Act. All participants provided informed consent to participate in the KYRBWS and were guaranteed anonymity and all methods were carried out in accordance with relevant guidelines and regulations.

- **Availability of data and materials**

All data used in this study are publicly available on the KYRBWS website(https://www.kdca.go.kr/yhs/).

- **Competing interests**

The authors declare that they have no competing interests.

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- **Authors' contributions**

Dahyun Kim: literature search, data analysis, writing – original draft, writing – revised; Woorim Kim: methodology, writing – original draft, writing – revised; Mingee Choi: study design, methodology, data interpretation, writing – revised ; Jaeyong Shin: supervision, conceptualization, project administration.

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Figures

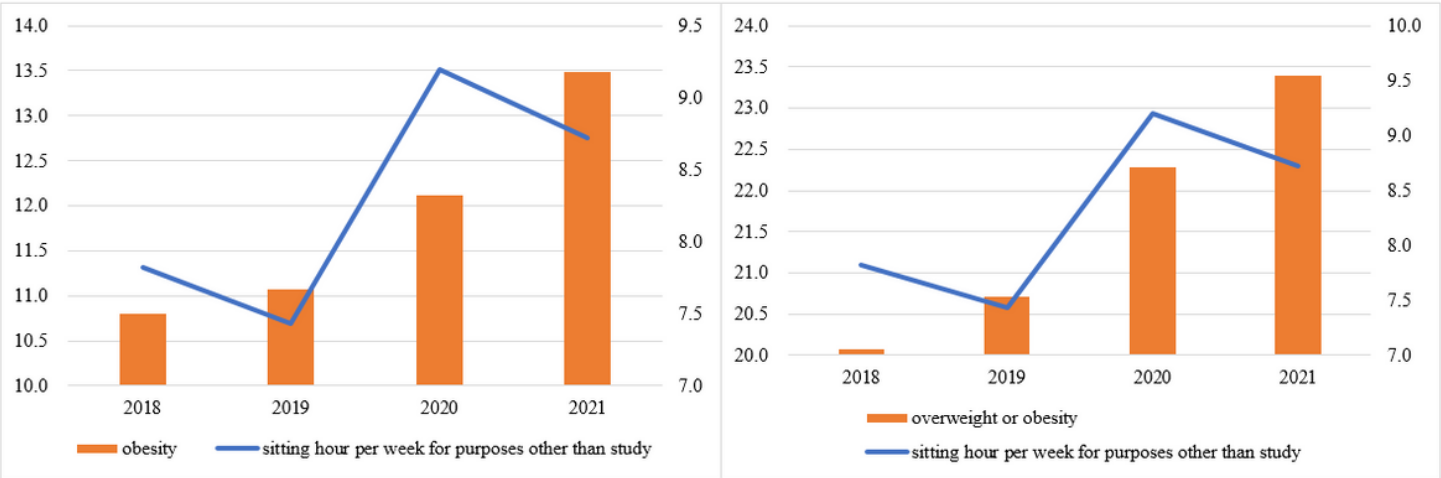

Figure 1

Trend of adolescents with obesity and overweight or obesity with sitting hour per week for purposes other than study

Supplementary Files

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- SupplementsCOVIDmovement.docx