The Impacts of the COVID-19 Pandemic on Academic Achievement According to Sex among Korean Adolescents and the Associated Health Behaviors

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Abstract

Background: After the outbreak of coronavirus disease 2019 (COVID-19), this study aimed to (1) identify whether the impacts of the COVID-19 pandemic on students' academic achievement differed according to their sex among Korean adolescents, and (2) investigate the health-related behavioral factors affecting their academic achievement during the COVID-19 pandemic.
Methods: Herein, secondary data of the cross-sectional 15th–17th (2019–2021) Korea Youth Risk Behavior Web-based Survey were used, targeting adolescents in middle and high school. A total of 167,099 individuals were selected and analyzed for self-reported academic grades and health behaviors using ordinal logistic regression analysis of the obtained results were compared to the pre-COVID-19 pandemic data in this regard (2019).
Results: High academic achievement in male adolescents significantly declined from 15.4% to 13.7% or 14.0% in 2019, 2020, and 2021, respectively. Compared to 2019, lower academic achievement was found in boys in 2020 and 2021 (odds ratio [OR]=0.93, 95% confidence interval [CI]=0.89-0.97, P=0.002 and OR=0.95, 95% CI=0.91-0.99, P=0.010) while no significant differences were observed in girls. In boys in 2020 or 2021, the lowered academic achievement was associated with the time of internet use for leisure during both weekdays and weekends, unhealthy health status, poor self-perceived health, a "fat" body image, stress, and skipping breakfast, stress, which increased during the COVID-19 pandemic, as well as engaging in personal hygiene, smoking, and alcohol drinking (P<0.05).
Conclusions: To improve academic achievement in the ongoing COVID-19 pandemic, it is necessary to develop and implement interventions, especially for male students, focusing on health management and targeting the associated health behaviors.

Keywords: COVID-19, Adolescents, Academic success, Health behavior, Korea

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1. Introduction

In November 2019, coronavirus disease 2019 (COVID-19) occurred in Wuhan, China. As the virus spread rapidly around the world due to its high contagiousness, the World Health Organization announced it on March 11, 2020 to be a pandemic (1). To prevent the spread of COVID-19 (2), in 2020, many governments, including the Korean government, applied social distancing policies that incorporated school closures and lasted until 2021 (3). The COVID-19 pandemic and its related policies have had impacts on individual lives, in addition to societies, economy, and education, worldwide (4-6).

Adolescents, who are in a period struggling with the establishment of their identity in their transition to adulthood, are particularly vulnerable to changes in the social environment. While social distancing was in effect, schools were closed or restrictions were placed on the number of students attending in each stage of social distancing in Korea (3). The changes in adolescents' social environment caused by the COVID-19 pandemic, such as online classes and homeschooling, have been reported to have adversely affected their psychological state, leading to problems such as internet addiction and psychiatric diseases, including attention deficit hyperactivity disorder, their health-associated behaviors, such as insomnia, and their negative emotions, including anxiety and depression (7-10).

Academic achievement during adolescence is important and can predict a person's social success and lifelong career trajectory (11). However, a review study was conducted on the effect of COVID-19-related school closures on academic achievement

among students worldwide in elementary and secondary schools (12). It reported mixed results although the majority of studies have reported worsened outcomes, especially among younger students and those with lower socioeconomic status (SES) (12). Therefore, the effects of the COVID-19 pandemic on adolescents' academic achievement and learning inequalities have raised concerns of many educators and researchers (12). Adverse health and health behaviors have been reported to be positively associated with negative academic achievement (13). However, no studies have explored the differences between sexes in terms of academic achievement during the COVID-19 pandemic and the reasons behind such differences. Contradictory results may stem from limited studies in a less diverse range of nations. In addition, studies in this regard were conducted immediately after the COVID-19 pandemic started (12). Hence, in order to obtain reliable research results, a study needs to be carried among a representative sample of Korean students over the entire multi-year period, during which social distancing policies were implemented.

Therefore, this study aimed to (1) identify whether the impacts of the COVID-19 pandemic on students' academic achievement differed according to their sex among Korean adolescents, and (2) investigate health-related behavioral factors affecting academic achievement during the COVID-19 pandemic. The current study will provide basic data to help improve adolescents' academic achievement and support effective health interventions for adolescents in the context of the ongoing COVID-19 pandemic.

2. Methods

2.1. Design and Participants

This study was a secondary analysis using raw data from the cross-sectional 15th (2019), 16th (2020), and 17th (2021) Youth Health Behavior Online Survey (KYRBS), aiming to identify the differences in the academic achievements of adolescents in Korea before (2019) and during the COVID-19 pandemic (2020 or 2021). The KYRBS data, provided by the Korea Centers for Disease Control and Prevention Agency (KCDCPA), were analyzed to obtain insights into the status of the health-related behavior of young people in the Republic of Korea. This analysis helped to calculate

the necessary health indicators for the planning and evaluation of youth health promotion projects, in addition to facilitating quantitative comparisons of youth health indicators among countries. The KYRBS is a cross-sectional study conducted annually on students aged 12–18 years at 400 middle schools and 400 high schools using a multi-stage cluster sampling design (14). A total of 167,099 respondents were analyzed during the three-year study period (2019–2021). More detailed material on the data, data collection, and the survey procedure is available online (https://knhanes.kdca.go.kr/knhanes/main.do). Ethical approval for the subjects of KYRBS was obtained by the institutional review board of the KCDCPA and informed consent was obtained from all the study subjects.

2.2. Measures

KYRBS's questions proposed by KCDCPA and the Ministry of Education, the Ministry of Health and Welfare, and the Ministry of Gender Equality and Family in Korea were reviewed by 15 academic advisory committees and a senior advisory committee specialized in adolescent health-risk behaviors and academy. KCDCPA approved good validity, by including the indicators only proposed through the Delphi survey and the advisory committee, as well as the reliability of the questions, whose test-retest reliability agreement ranged between 77.6% and 100% for all indices (15).

As the outcome variable, academic achievement was measured based on self-reported academic grades in a 12-month period via a five-point scale from 1 to 5 (low, middle-lower, middle, middle-upper, and high respectively). As for covariate and independent variables, sociodemographic characteristics, health, and health-related behaviors were included. Health and health-related behaviors comprised subjective health status, perceived body image, stress, breakfast consumption, physical activity, sleeping adequacy, the time of internet use for studying and leisure during weekdays and weekends, personal hygiene, and current status of smoking and alcohol drinking. Health status and perceived body image were subjectively evaluated by the respondents, whose responses were reclassified into healthy (very healthy or healthy), average, and unhealthy (unhealthy or very unhealthy), and thin (very thin or thin), average, and fat (fat or very fat). All the variables associated with health-

related behavior were measured as "yes" or "no," except for the time of internet use. The responses were reclassified as "yes" for stress, breakfast consumption, physical activity, and sleeping adequacy based on the responses of "very much stress" or "much stress" from five items about how stressed they felt on a daily basis; the responses of more than five days for the frequency of breakfast consumption in the preceding 7 days; the responses of more than 3 days for the number of days of physical activity in the preceding 7 days (in which their heart rate was higher than usual or whether they engaged in 60 minutes or more of physical activity that left them breathless, regardless of the type of physical activity); the responses of "more than enough" and "enough" sleeping time from five items about how much felt recovering from fatigue in the preceding 7 days. All the other responses were classified as "no" for those variables. The time of internet use was assessed based on how many hours per day on average the participants used the internet for studying and leisure during weekdays and weekends, respectively, over the previous 7 days. A response of "yes" for personal hygiene was defined as a score of 10 points and above for how often hands were washed with soap in the past 7 days. A total of 20 points was considered as the possible score for this factor, with respect to the followings: before meals in school, after using the bathroom at school, before meals at home, after using the bathroom at home, and after coming home, with responses of "always," "mostly," "sometimes," and "never" corresponding to scores of 1 to 4. Responses of "yes" for current smoking and drinking were defined based on whether the participants had smoked more than one cigarette a day or drunk more than one drink over the last 30 days.

Sociodemographic characteristics included sex, age, school type (middle school or high school), household SES (assessed by self-reported responses of low, middle-low, middle, high-middle, or high), and multicultural family (determined based on the response to a yes/no question asking whether one or both their parents were born in Korea).

2.3. Statistical Analyses

The KYRBS used a stratified multi-stage cluster-sampling design to provide representative estimates of the Korean population. Complex-sample frequency analysis was performed to calculate the unweighted frequencies and weighted percentages. Moreover, the estimated mean and standard error were calculated in a complex-sample descriptive statistical analysis. Utilizing the Rao-Scott test and the combined-sample t-test, we analyzed the differences in terms of sociodemographic and health-related behavioral characteristics and academic achievements comparing before (2019) and during (2020 or 2021) the COVID-19 pandemic according to their sex. The impacts of the COVID-19 pandemic on academic achievement according to sex and the associated health-related behavioral variables were analyzed in a complex sample using ordinal logistic regression in comparison with before the COVID-19 pandemic (2019), after adjusting for sociodemographic characteristics. The statistical analysis was carried out via SPSS version 27.0, with a significance level of 5%.

3. Results

The male participants of the study in 2019 were about 15 years old on average and had the following noteworthy characteristics: 42.4% resided in a middle or higher-SES household, 1.8% were from multicultural families, 5.8% rated their health status as unhealthy, 36.0% considered their body image as fat, 31.7% reported having stress, 51.9% regularly consumed breakfast, 46.1% engaged in physical activities, 26.9% had sufficient sleeping time, the average time of internet was 7.06 and 3.70 hours for studying and 2.77 and 4.79 hours for leisure during weekdays and weekends, respectively, 69.4% engaged in handwashing, 9.3% smoked, and 16.9% drank alcohol. Compared to 2019, in 2020 and 2021, male adolescents were significantly more likely to be older (P=0.002), have lower high household SES (P=0.003), be from a multicultural family (P=0.002), have an unhealthy subjective health status (P<0.001), and a fat perceived body image (P<0.001); furthermore, they less frequently engaged in breakfast consumption (P<0.001) or physical activities (P<0.001), had better sleeping time (P<0.001), spent more time using the internet for leisure during both weekdays (P<0.001) and weekends (P<0.001), were more likely to routinely engage in personal hygiene (P<0.001), and were less likely to smoke (P<0.001) and drink alcohol (P<0.001). In 2020, they were much more likely to have less stress (P<0.001) (Table 1).

In 2019, the female subjects were also about

Table 1: Sociodemographic and health-related characteristics of study participants and their differences from 2019 to 2021 according to sex (N=167099) n (%)

Variables		Male				Female			
		2019 (n=29841)	2020 (n=28353)	2021 (n=28401)	P	2019 (n=27462)	2020 (n=26595)	2021 (n=26447)	P
Age	(mean±SD)	15.09±0.04	15.20±0.04	15.24±0.04	0.002	15.07±0.05	15.17±0.04	15.21±0.04	0.006
School type	Middle school	15401 (47.7)	14830 (49.4)	15586 (50.8)	0.497	13983 (48.1)	14131 (49.9)	14429 (51.2)	0.608
	High school	14440 (52.3)	13523 (50.6)	12815 (49.2)		13479 (51.9)	12464 (50.1)	12018 (48.8)	
Household SES	High	4019 (13.6)	3536 (12.7)	3563 (12.6)	0.003	2360 (8.7)	2503 (9.6)	2381 (9.0)	<0.001
	Middle upper	8566 (28.8)	8087 (29.3)	8248 (29.6)		7560 (28.1)	7213 (27.9)	7376 (28.9)	
	Middle	13561 (45.3)	13013 (45.2)	13321 (46.6)		13896 (50.4)	13384 (50.0)	13756 (51.5)	
	Middle lower	2950 (9.8)	2995 (10.3)	2619 (9.0)		3092 (11.0)	2942 (10.5)	2472 (8.9)	
	Low	745 (2.5)	722 (2.4)	650 (2.2)		554 (1.9)	553 (1.9)	462 (1.6)	
Multicultural family	Yes	340 (1.8)	467 (2.0)	536 (2.4)	0.002	371 (1.6)	518 (2.1)	559 (2.4)	<0.001
	No	16336 (98.2)	18750 (98.0)	18030 (97.6)		18489 (98.4)	20172 (97.9)	19672 (97.6)	
Subjective health status	Healthy	22844 (76.1)	21550 (74.3)	19831 (69.7)	<0.001	17412 (63.3)	17294 (64.6)	15698 (59.3)	<0.001
	Average	5318 (18.1)	5449 (19.4)	6334 (22.2)		7492 (27.4)	6893 (26.1)	7964 (30.2)	
	Unhealthy	1679 (5.8)	1754 (6.3)	2236 (8.1)		2558 (9.3)	2408 (9.2)	2785 (10.5)	
Perceived body image	Thin	9200 (30.9)	8149 (28.9)	8334 (29.6)	<0.001	5350 (19.7)	5175 (19.6)	5495 (21.0)	<0.001
	Average	9929 (33.1)	9125 (32.4)	8938 (31.5)		10799 (39.3)	10724 (40.4)	10637 (40.5)	
	Fat	10712 (36.0)	11079 (38.7)	11129 (38.9)		11313 (41.1)	10696 (40.0)	10315 (38.5)	
Stress	Yes	9395 (31.7)	7849 (28.1)	9168 (32.3)	<0.001	13383 (48.8)	10813 (40.7)	12077 (45.6)	<0.001
	No	20446 (68.3)	20504 (71.9)	19233 (67.7)		14079 (51.2)	15782 (59.3)	14370 (54.4)	
Breakfast consumption	Yes	15520 (51.9)	14102 (49.8)	13895 (48.6)	<0.001	12800 (47.1)	11562 (44.2)	11791 (44.9)	<0.001
	No	14321 (48.1)	14251 (50.2)	14506 (51.4)		14662 (52.9)	15033 (55.8)	14656 (55.1)	
Physical activity	Yes	14019 (46.1)	11963 (41.1)	12837 (44.1)	<0.001	5970 (21.2)	5744 (20.8)	6490 (23.7)	<0.001
	No	15822 (53.9)	16390 (58.9)	15564 (55.9)		21492 (78.8)	20851 (79.2)	19957 (76.3)	
Sleeping adequacy	Yes	8328 (26.9)	9960 (34.7)	8115 (27.8)	<0.001	4323 (15.4)	6864 (25.6)	4724 (17.6)	<0.001
	No	21513 (73.1)	18393 (65.3)	20286 (72.2)		23139 (84.6)	19731 (74.4)	21723 (82.4)	
Internet use time for study during weekdays	(hour) (mean±SD)	7.06±0.06	6.49±0.06	7.06±0.05	0.990	8.58±0.05	7.43±0.05	8.28±0.04	<0.001
Internet use time for leisure during weekdays	(hour) (mean±SD)	2.77±0.02	3.79±0.02	3.49±0.02	<0.001	2.82±0.02	3.87±0.02	3.50±0.02	<0.001
Internet use time for study during weekends	(hour) (mean±SD)	3.70±0.06	3.38±0.06	3.64±0.06	0.443	4.37±0.06	3.74±0.06	4.21±0.06	0.063
Internet use time for leisure during weekends	(hour) (mean±SD)	4.79±0.03	5.42±0.03	5.40±0.03	<0.001	4.67±0.03	5.40±0.03	5.13±0.03	<0.001
Personal hygiene	Yes	20642 (69.4)	21843 (77.0)	20969 (74.2)	<0.001	17843 (65.3)	21193 (80.1)	20289 (77.2)	<0.001
	No	9199 (30.6)	6510 (23.0)	7432 (25.8)		9619 (34.7)	5402 (19.9)	6158 (22.8)	
Current smoking	Yes	2630 (9.3)	1725 (6.0)	1629 (6.0)	<0.001	1063 (3.8)	745 (2.7)	775 (2.9)	<0.001
	No	27211 (90.7)	26628 (94.0)	26772 (94.0)		26399 (96.2)	25850 (97.3)	25672 (97.1)	
Current drinking consumption	Yes	4841 (16.9)	3427 (12.1)	3415 (12.4)	<0.001	3559 (13.0)	2465 (9.1)	2388 (8.9)	<0.001
	No	25000 (83.1)	24926 (87.9)	24986 (87.6)		23903 (87.0)	24130 (90.0)	24059 (91.1)	

Unweighted frequency (weighted %), estimated mean±standardized error

15 years old on average and had the following noteworthy characteristics: 36.8% resided in middle and higher-SES households, 1.6% were from multicultural families, 9.3% rated their health status as unhealthy, 41.1% considered their body image as fat, 48.8% reported having stress, 47.1% regularly consumed breakfast, 21.2% engaged in physical activities, 15.4% had sufficient sleeping time, the average time of internet use was 8.58 and 4.37 hours for studying and 2.82 and 4.67 hours for leisure during weekdays and weekends, respectively, 65.3% engaged in handwashing for

personal hygiene, 3.8% smoked, and 13.0% drank alcohol. Compared to 2019, in 2020 and 2021, female adolescents showed similar tendencies to those of male adolescents, except for being less likely to perceive their body image as fat (P<0.001) and spending less time on the internet for studying on weekdays (P<0.001).

The percentages of male adolescents with high academic achievement were 15.4%, 13.7%, and 14.0% in 2019, 2020, and 2021, respectively, showing a statistically significant difference; meanwhile, the proportions with low academic achievement were 10.3%, 11.1%, and 10.8% respectively in the same years (P<0.001). The academic achievement of female adolescents showed no statistically significant differences during the study period, with about 10.7% having high and 9.1% low academic achievement (P=0.139) (Table 2).

Table 3 represents the impacts of the COVID-19 pandemic on academic achievements according to sex. After adjusting for sociodemographic characteristics, compared to 2019, academic achievement showed significant differences, with a 0.93-time lower likelihood of high academic performance in 2020 (odds ratio [OR]=0.93, 95% confidence interval [CI]=0.89-0.97, P=0.002) and a 0.95-time lower likelihood in 2021 (OR=0.95, 95% CI=0.91-0.99, P=0.010) in the male adolescents. Nonetheless, no significant differences were found in the female adolescents between 2019 and neither 2020 nor 2021.

Table 4 depicts the associated health -related behavioral variables with academic achievement during the COVID-19 pandemic according to sex. In 2020, after adjusting for sociodemographic characteristics among the male subjects, the followings were found to be associated with lower academic achievement: average or unhealthy subjective health status compared to healthy status (P<0.001, P<0.001 respectively), a fat perceived body image compared to a thin body image (P<0.001), stress (P<0.001), skipping breakfast (P<0.001), less time of internet use for studying on both weekdays and weekends (P<0.001 and P<0.001 respectively) and more time of internet use for leisure on both weekdays and weekends (P=0.011 and P=0.048 respectively), engaging in personal hygiene (P=0.027), smoking (P<0.001), and alcohol drinking (P=0.004). In 2021, these associations were no longer present for the time of internet use for leisure (P=0.175) and engaging in personal hygiene (P=0.682).

In 2020, among the female adolescents, lower academic achievement were attributed to the followings: average or unhealthy subjective health status compared to healthy status (P=0.001, P<0.001 respectively), an average or fat perceived body image compared to a thin body image (P=0.002, P<0.001 respectively), stress (P=0.002), skipping breakfast (P<0.001), engaging in physical activity (P=0.022), inadequate sleeping time (P<0.001), less time of internet use for studying on both weekdays and weekends (P<0.001 and P<0.001 respectively)

Table 2: Academic achievement and its differences in 2020 or 2021 compared to 2019 according to sex n (%)

Variables		Male				Female			
		2019 (n=29841)	2020 (n=28353)	2021 (n=28401)	P	2019 (n=27462)	2020 (n=26595)	2021 (n=26447)	P
Academic achievement	High	4661 (15.4)	3853 (13.7)	4045 (14.0)	<0.001	2986 (10.7)	2883 (10.7)	3039 (11.3)	0.139
	Middle-upper	7254 (24.2)	6735 (24.0)	6757 (23.7)		7042 (25.6)	6675 (25.4)	6687 (25.3)	
	Middle	8615 (28.9)	8281 (28.9)	8518 (30.0)		8619 (31.5)	8304 (31.5)	8385 (32.1)	
	Middle-lower	6251 (21.1)	6384 (22.5)	6029 (21.5)		6319 (23.0)	6300 (23.6)	5975 (22.5)	
	Low	3060 (10.3)	3100 (11.1)	3052 (10.8)		2496 (9.1)	2433 (8.9)	2361 (8.8)	

Unweighted frequency (weighted %)

Table 3: The impacts of the COVID-19 pandemic on academic achievements according to sex

	2020						2021					
	Male			Female			Male			Female		
	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Year 2020 or 2021 vs. 2019	0.93	0.89~0.97	0.002	0.98	0.95~1.02	0.434	0.95	0.91~0.99	0.010	1.01	0.97~1.04	0.81

Adjusting for age, school type, household SES, and multicultural family.

Table 4: Associations of health behavioral variables with academic achievement in 2020 or 2021 according to sex after adjusting for sociodemographic characteristics

	2020 vs. 2019						2021 vs. 2019					
	Male			Female			Male			Female		
	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Subjective health status												
Average vs. healthy	0.78	0.71~0.86	<0.001	0.93	0.88~0.97	0.001	0.86	0.82~0.90	<0.001	0.89	0.85~0.93	<0.001
Unhealthy vs. healthy	0.85	0.81~0.90	<0.001	0.87	0.81~0.94	<0.001	0.74	0.67~0.81	<0.001	0.80	0.74~0.86	<0.001
Perceived body image												
Average vs. thin	0.99	0.93~1.03	0.399	0.92	0.88~0.97	0.002	0.99	0.94~1.04	0.677	0.89	0.84~0.93	<0.001
Fat vs. thin	0.87	0.83~0.91	<0.001	0.74	0.70~0.78	<0.001	0.85	0.81~0.90	<0.001	0.72	0.68~0.76	<0.001
Stress Yes vs. no	0.91	0.87~0.95	<0.001	0.86	0.82~0.90	<0.001	0.93	0.89~0.98	0.003	0.89	0.87~0.93	<0.001
Breakfast consumption												
Yes vs. no	1.48	1.42~1.54	<0.001	1.49	1.44~1.55	<0.001	1.51	1.44~1.57	<0.001	1.48	1.42~1.53	<0.001
Physical activity												
Yes vs. no	1.03	0.99~1.07	0.207	0.95	0.90~0.99	0.022	1.03	0.98~1.07	0.256	0.94	0.90~0.98	0.006
Sleeping adequacy												
Yes vs. no	1.05	1.00~1.09	0.050	1.08	1.03~1.13	0.002	1.03	0.98~1.08	0.244	1.09	1.03~1.15	0.004
Internet use time for study (hour) during weekdays	1.05	1.04~1.07	<0.001	1.07	1.04~1.10	<0.001	1.05	1.03~1.06	<0.001	1.07	1.04~1.10	0.011
Internet use time for leisure (hour) during weekdays	0.96	0.93~0.99	0.011	0.94	0.91~0.98	0.004	0.92	0.89~0.95	<0.001	0.94	0.91~0.98	0.002
Internet use time for study (hour) during weekends	1.08	1.06~1.11	<0.001	1.07	1.04~1.10	<0.001	1.10	1.08~1.13	<0.001	1.10	1.07~1.13	<0.001
Internet use time for leisure (hour) during weekends	0.97	0.95~0.99	0.048	1.02	0.99~1.04	0.255	0.99	0.96~1.01	0.175	1.02	0.99~1.05	0.154
Personal hygiene												
Yes vs. no	0.94	0.91~0.99	0.027	0.93	0.89~9.98	0.004	1.01	0.97~1.06	0.682	0.97	0.93~1.02	0.971
Current Smoking												
Yes vs. no	0.56	0.51~0.62	<0.001	0.54	0.47~0.63	<0.001	0.58	0.53~0.64	<0.001	0.55	0.48~0.63	<0.001
Current drinking consumption												
Yes vs. no	0.90	0.84~0.97	0.004	0.85	0.80~0.92	<0.001	0.93	0.87~0.99	0.034	0.91	0.84~0.98	0.012

OR: Odds Ratio

and more time of internet use for leisure during weekdays (P=0.004), engaging in personal hygiene (P=0.004), smoking (P<0.001), and alcohol drinking (P<0.001). In 2021, there was no longer an association between lower academic achievement and engaging in personal hygiene (P=0.971).

4. Discussion

This study was conducted to identify whether the impacts of the COVID-19 pandemic on students' academic achievement differed according to their sex among Korean adolescents and to investigate the health-related behavioral factors affecting academic achievement during the COVID-19 pandemic by using representative 15th (2019) to 17th (2021) KYRBS data after adjusting for sociodemographic characteristics in comparison to the findings from 2019.

As for the impacts of the COVID-19 pandemic on students' academic achievement according to sex, this study found that male students' academic achievement significantly decreased during the COVID-19 pandemic. However, there was no difference in female students concerning this factor. Additionally, the impacts were more profound in high-achieving students than low-achieving ones, which is not in line with the results of a systematic review study (12). Although sex comparison is difficult due to the lack of previous studies, the difference in academic performance based on sex after the COVID-19 pandemic seems to be on account of male students being more vulnerable to problems with health management and unhealthy behaviors compared with their

female counterparts. Male students tend to show less interest in and adherence to health care (16, 17), as well as a higher tendency to engage in risky health behaviors (17, 18), which eventually lead to poor health outcomes (17) and lower academic performance.

In particular, it is necessary to pay attention to health behaviors significantly related to the academic achievement of male students in this study; that is, unhealthy health status, a fat perceived body image, stress, skipping breakfast, the time of internet use for leisure during both weekdays and weekends, engaging in personal hygiene, smoking, and alcohol drinking. Primarily, the association of internet use time for leisure during both weekdays and weekends with lowered academic achievement has been substantiated by several papers, suggesting that longer time of internet use adversely influenced students' academic performance (19, 20). Internet use disrupts students from studying in an uninterrupted environment, where students do not have to engage in multitasking. This, consequently, leads to a decline in academic achievement (21, 22). The negative impact of internet use was more conspicuous among male students, which is consistent with the findings herein, suggesting that the time of internet use for leisure during only weekdays was associated with lowered academic achievement in female adolescents. It could be speculated that the differences in multitasking ability according to sex might explain this result as a number of studies have shown that males have worse multitasking performance than females (23, 24). Male students are also more susceptible to internet addiction (25). As adolescents spend more time participating in distance learning than at school due to the COVID-19 pandemic, there is a need to develop a program that can improve self-directed handling time of internet use in order to increase their academic achievement, especially in male students (26).

The other health-related behaviors that were significantly related to the academic achievement of male students are similar to those of the female subjects in this study. Secondly, unhealthy health status and a fat perceived body image, which consistently increased during the COVID-19 pandemic, were associated with lowered academic achievement in this study; that is, worse health status (obesity) seems to have a negative effect on academic achievement (27). Despite the fact that

men are more positive about their health than women and are less concerned with their body image in terms of size because they want to be physically larger (17), male students responded more often that they were unhealthy and rated their body as fat more frequently than female students herein. Their worsened health status during the COVID-19 pandemic seems to have had a significant impact on their academic achievement.

Thirdly, stress was found to be associated with lowered academic achievement in this study. People infected with COVID-19, self-quarantined people, and adolescents are vulnerable to mental health issues, such as depression, anxiety, and acute stress response in a pandemic situation (28, 29). In particular, adolescents are more significantly affected by socio-ecological influences when vulnerabilities in the surrounding environment occur due to COVID-19 (30). Fourth, skipping breakfast, drinking, and smoking were associated with lowered academic achievement in this study. These associations have been indicated in many previous studies (18, 31), but in the era of the COVID-19 pandemic, it seems as if the proportion of adolescents feeling unhealthy and overweight/obese may have increased due to the greater frequency of irregular eating, including skipping breakfast. However, deviant behaviors, such as drinking and smoking, decreased among adolescents in social isolation (32). Lastly, engaging in personal hygiene was associated with lowered academic achievement in this study. Washing hands, which was recommended as a quarantine policy seems to have been performed due to perceptions of that being a civic duty and fears of infecting family (33). Compliance with handwashing is the highest duty after the COVID-19 attack, which then gradually decreases. Concerns about family's health seem to have an impact on academic performance as well.

4.1. Limitations and Strengths

This study has several limitations and strengths. The measured variables, including academic achievement, were all self-rated and constructed by a single corresponding question; thus, they were subjected to measurement error, limiting the interpretation of this study's results. However, it has been found that students' self-reported grades have a very close correlation with actual grades (15, 34). Despite these limitations, this study analyzed a sample of Korean adolescents representing the

nation. The current research also provided data on academic achievement, with certain potential implications for steps that could be implemented to improve academic achievement during the ongoing COVID-19 pandemic.

5. Conclusions

In conclusion, this study found that academic achievement decreased during the COVID-19 pandemic in Korean male adolescents, but not in female adolescents. Furthermore, the lowered academic achievement among male students was associated with the time of internet use for leisure during both weekdays and weekends, unhealthy health status, poor self-perceived health, a fat body image, stress, and skipping breakfast, COVID-19 pandemic-related stress, as well as engaging in personal hygiene, smoking, and alcohol drinking. To improve academic achievement in the ongoing COVID-19 pandemic, it is necessary to develop and implement interventions, especially for male students, taking into consideration health management that targets the time of internet use as well as the other associated health-related behaviors.

Ethical Approval

Ethical approval for the subjects of KYRBS was obtained by the institutional review board of the KCDCPA and informed consent was obtained from all the study subjects.

Conflict of Interest: None declared.

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