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Effects of COVID-19 Outbreak on Korean Adolescents: Impact of Altered Socio-Economic Perception on Physical Activity, Sedentary Behavior, and Stress Levels in an Age-, Gender-, and BMI-Matched Study

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Abstract: The current study is to examine the disparities in physical activity (PA), sedentary behavior (SB), and stress levels in Korean adolescents in relation to changes in their perception of family socio-economic status (SES) during the COVID-19 pandemic. A total of 6144 Korean adolescents participated in this research. The participants were categorized into two groups based on their responses regarding changes in their family's SES during COVID-19: the Lower SES group (n = 3072) and the Non-changed SES group (n = 3072), with matching in terms of age, gender, and BMI. Various variables, including PA, SB, stress, and perception of changes in SES, were assessed in adolescents aged 12 to 18 years who participated in the 16th year (2020) of the Korean Youth Risk Behavior Survey (KYRBS). Statistical analyses were conducted using SPSS 26.0 version, employing independent *t*-tests to examine anthropometrics' differences and multinominal logistic regression to predict the impact of perception of family SES on PA, SB, and stress variables, while comparing the Lower SES group and the Non-changed SES group. The significance level was set at $\alpha = 0.05$. Adolescents in the Lower SES group were less likely to engage in vigorous-intensity PA (VPA) and muscular strength activities compared to those in the Non-changed SES group ($p < 0.001$). However, no significant differences were observed in total PA between the two groups. Furthermore, adolescents in the Lower SES group were 2.3 times more likely to experience a very severe level of stress compared to the Non-changed SES group ($p < 0.001$). These results shed light on the importance of promoting VPA and muscular strength activities in adolescents for both their physical and mental well-being, particularly during potential future pandemics. Understanding the impact of perceived SES changes on health behaviors can inform targeted interventions and support strategies to improve the health outcomes of adolescents during challenging times.

Keywords: physical activity; sedentary behavior; stress; socio-economic status; adolescents; COVID-19

1. Introduction

Coronavirus disease 2019 (COVID-19) is an epidemic disease associated with severe respiratory syndromes, and in 2019, the World Health Organization (WHO) declared it a global public health emergency (Stasi, Fallani, Voller, & Silvestri, 2020). To curb the spread of the COVID-19 virus, social distancing measures were implemented worldwide during the pandemic, leading to the closure of schools and public facilities and limiting non-essential gatherings (Dawson, Ashcroft, Lorenz-Dant, & Comas-Herrera, 2020; E.-A. Kim, 2020; H. Kim, 2020).

Despite their effectiveness in reducing virus transmission, these necessary measures have unintended health-related consequences for children and adolescents. Specifically, the restrictions have resulted in decreased participation in physical activity (PA) (Bates et al., 2020; Guerrero et al., 2020; Moore et al., 2020; Zenic et al., 2020), increased sedentary behavior (SB) (Bates et al., 2020; Margaritis et al., 2020; Vanderloo et al., 2020), and disrupted sleep patterns (Bates et al., 2020; Becker & Gregory, 2020; J. Lee, 2020) among the youth. Such reductions in PA and increased SB carry significant risks for the long-term health of young individuals, potentially contributing to the development of various chronic diseases that may persist into adulthood (Physical Activity Guidelines Advisory Committee, 2008). In light of these concerns, the WHO issued guidelines in 2020, recommending that children and adolescents engage in a minimum of 60 minutes or more of moderate-to-vigorous PA (MVPA) daily, including regular aerobic and muscle-strengthening activities at least three days a week (Chaput et al., 2020). Unfortunately, the COVID-19 outbreak and the subsequent restrictions have limited the opportunities for youth to engage in PA-related activities (Schmidt et al., 2020).

In addition to its direct impact on the youth's health, the COVID-19 pandemic and the consequent restrictions have had a substantial effect on families' socioeconomic status (SES), including the economic crisis, income loss, and unemployment (Dang & Nguyen, 2021). These socioeconomic changes are indirectly associated with the health-related behaviors of the youth (Buzek et al., 2019; Reiss et al., 2019). Extensive research has consistently demonstrated significant associations between family SES and health-related behaviors among youth individuals. Studies have revealed that adolescents from high-income families tend to engage in more MVPA and experience lower levels of inactivity compared to counterparts from low-income families (Bauman et al., 2012; Bauman, Sallis, Dzewaltowski, & Owen, 2002; Gordon-Larsen, McMurray, & Popkin, 2000). Conversely, research has indicated that children from low SES families face a higher risk of various health-related issues, such as sleep deficiency, overweight, academic stress, and other mental health problems (Bagley & El-Sheikh, 2013; Buzek et al., 2019; Hassan, Davis, & Chervin, 2011; Reiss et al., 2019). Additionally, several studies have emphasized the significant association between parental support and youth's engagement in PA (Rhodes & Lim, 2018; Rhodes et al., 2019; Yun et al., 2018). Considering this existing evidence, it is reasonable to hypothesize that the socioeconomic impact of COVID-19 may influence children's daily PA, possibly mediated by parental support (Moore et al., 2020).

In light of the importance of exploring the interplay between external factors, family processes, and children's perceptions (Conger, Conger, & Martin, 2010; Goodenow, 1993), it becomes essential to consider the impact of COVID-19 on family SES and how it may have influenced children's perception of their family's SES, irrespective of the actual family SES. Thus, alongside actual family SES, gaining insight into children's perception of their family SES becomes imperative to fully comprehend the multifaceted relationship between socioeconomic factors and health-related behaviors in youth during the COVID-19 pandemic.

Therefore, the primary objective of this study is to investigate the associations between PA, SB, and perceived stress among Korean adolescents. Specifically, we aim to focus on changes in the perception of family SES during the COVID-19 outbreak in 2020, a period characterized by widespread implementation of social distancing measures and restrictions.

2. Materials and Methods

2.1. Study Design

The KYRBS is a cross-sectional survey that was initiated in 2005 by the Korean Ministry of Education, the Ministry of Health and Welfare, and the Korean Centers for Disease Control and Prevention (KCDCP). The survey is designed to evaluate the risk of health-related behaviors in 15 areas (e.g., SES, PA, and mental health) among youths in South Korea. The validity and reliability of KYRBS's questionnaire have been demonstrated in previous studies (Bae et al., 2010). In this study, we assessed the variables of PA, SB, stress, and perception of changes in SES were assessed in

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adolescents aged 12–18 years who agreed to participate in the 16th year (2020) of the KYRBS. Since this survey is an online anonymous survey that does not collect any personal information of the participants, it was not necessary to obtain ethical approval from an institutional review board (IRB). The data of KYRBS is the government-approved statistical survey (No. 117058) based on Article 18 of the Statistical Act of the Republic of Korea.

2.2. Study participants

A total of 57,925 Korean adolescents from 800 schools (400 from middle schools and 400 from high schools) responded to the 2020 KYRBS survey. After excluding adolescents who did not respond and missing data, the final sample consisted of 54,948 participants. The current study divided the participants into two groups: those who responded that their family's SES had been lower after COVID-19 (Lower SES; n = 3072) and those who responded that their family's SES did not change (Non-changed = 3072). To ensure that the two groups were comparable, participants who responded that their family's SES did not change were matched in age, gender, and BMI to the Lower SES group. Therefore, a total of 6144 participants were included in this study.

Table 1 summarizes the participants' demographic information. The study participants consisted of 54.9% of boys and 45.1% of girls who were in middle school or high school. The participants' anthropometric information was presented as mean and standard deviation (SD). The mean height, weight, and BMI for boys were 171.24 ± 7.84 cm, 65.80 ± 13.78 kg, and 22.33 ± 3.91 kg·m^{-2}, respectively, and the mean height, weight, and BMI for girls were 161.10 ± 5.38 cm, 53.86 ± 9.42 kg, and 20.72 ± 3.22 kg·m^{-2}, respectively. The results of the independent *t*-test showed no significant differences in height, weight, and BMI between the two groups ($p > 0.05$). The Low SES group had a higher percentage of individuals with academic performance in the low to middle level (67.5%), whereas the Non-changed SES group had more individuals in the middle to high level (77.1%). Additionally, the Lower SES group had a larger population of individuals in the low to middle classes of actual family SES (73.9%), while the Non-changed SES group had a higher representation in the middle to high classes (95.9%). A detailed description is presented in Table 1.

Table 1. Participants' characteristics and anthropometrics information between the Lower SES group and Non-changed SES group.

Variable			Lower SES Group (n = 3,072)		Non-changed Group (n = 3,072)	
			No. (%)	Mean ± SD	No. (%)	Mean ± SD
Age (year)	Boys		1,760 (57.3)	15.15 ± 1.81	1,612 (52.5)	14.89 ± 1.78
	Girls		1,312 (42.7)	15.27 ± 1.78	1,460 (47.5)	14.85 ± 1.72
Anthropometrics	Boys	Height (cm)		171.31 ± 8.01		171.16 ± 7.66
		Weight (kg)		66.30 ± 14.60		65.29 ± 12.95
		BMI (kg·m^{-2})		22.46 ± 4.07		22.20 ± 3.74
	Girls	Height (cm)		160.99 ± 5.55		161.21 ± 5.20
		Weight (kg)		55.12 ± 10.11		52.65 ± 8.72
		BMI (kg·m^{-2})		21.22 ± 3.43		20.22 ± 3.00
Education	Middle School		1,545 (50.3)		1,845 (60.0)	
	High School		1,527 (49.7)		1,227 (40.0)	
Academic Performance	High		383 (12.5)		665 (21.6)	
	Middle-High		615 (20.0)		897 (29.2)	
	Middle		774 (25.2)		809 (26.3)	
	Middle-Low		769 (25.0)		483 (15.7)	
	Low		531 (17.3)		218 (7.1)	
Family SES	High		331 (10.8)		829 (27.0)	
	Middle-High		471 (15.3)		1,183 (38.5)	
	Middle		1,109 (36.1)		933 (30.4)	
	Middle-Low		811 (26.4)		100 (3.3)	
	Low		350 (11.4)		27 (0.9)	

SES: Socio-Economic Status, SD: Standard Deviation, BMI: Body Composition Index; There are no significant differences in both Height and Weight between the Lower SES group and the Non-changed SES group ($p > .05$).

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2.3. Measures

Physical Activity. The daily PA was assessed using the following questions from the KYRBS; Total PA was asked as "How many days do you usually do a total of 60 minutes or more of moderate-intensity PA (any type) for a week?". An 8-point scale (i.e., 1 = Never, 2 = 1 day, 3 = 2 days, 4 = 3 days, 5 = 4 days, 6 = 5 days, 7 = 6 days, and 8 = every day) was added to the former question. The VPA and muscular strength activities were asked as "How many days do you usually do 20 minutes or more of VPA (i.e., jogging, playing soccer, basketball, taekwondo, mountain climbing, riding a bicycle or swimming at high speed, and carrying heavy objects) for a week?", and "How many days do you usually do muscular strength activities (i.e., push-ups, sit-ups, lifting weights, dumbbells, chin-up bar, and parallel bar) for a week?". Further, a 6-point scale (i.e., 1 = Never, 2 = 1 day, 3 = 2 days, 4 = 3 days, 5 = 4 days, and 6 = More than 5 days) was added to the former questions. The participants were grouped into 3 categories based on the number of days of participation in PA: an active group (> 3 days (4–7 days)), a normal active group (≤ 3 days (2–3 days)), and an inactive group (≤ 1 day (0–1 day)).

Sedentary Behavior. The SB variable was assessed by asking the following question; "How many hours do you usually sit in a day (i.e., sitting at a desk for studying or doing assignments, sitting with friends, moving by car, bus, or train, reading a book, writing, playing a card game, watching TV, playing a video/computer game, and using the Internet)?". The SB was calculated as the amount of sitting time (minutes per week). The participants were grouped into 3 categories based on their weekly sitting time (i.e., High SB (≥ 1380 minutes), Medium SB (920–1379 minutes), and Low SB (< 920 minutes)) for comparing differences in SB levels.

Stress. The perception of stress was assessed through the following question; "How much stress do you usually feel in your daily life?". A 5-point Likert Scale (i.e., 1 = Very Severe, 2 = Severe, 3 = Moderate, 4 = Mild, and 5 = Very Mild) was used for the perceived stress question.

Data analysis. All data obtained in this study were summarized by SPSS 26.0 version (SPSS Inc., Chicago, IL, USA). The participant's personal information (i.e., age, education, and socio-economic status) was examined by descriptive statistics, and anthropometrics information (i.e., height, weight, and BMI) were analyzed by an independent *t*-test to investigate the differences between the Lower SES group and the Non-changed SES group. Multinominal logistic regression was used to predict the impact of perception of family SES on the PA, SB, and stress variables comparing the Lower SES group and the Non-changed SES group by adjusting actual family SES and participants' academic performance, which is measured categorically as responded by high, middle-high, middle, middle-low, and low. The results were presented as odds ratios (OR) with 95% confidence intervals (95% CI). Additionally, we conducted a comparative analysis by presenting average participation days in PA, the time spent in SB per week, and stress levels between the Lower SES group and the Non-changed SES group. All statistical significances were set by $p < 0.05$.

3. Results

Table 2 presents the findings of multinomial logistic regression analysis investigating the influence of family SES perception on PA, SB, and stress levels while adjusting for actual family SES and participants' academic performance. The results reveal notable differences between the Lower SES group and the Non-changed group. Regarding PA, adolescents who perceived a lower family SES during COVID-19 were 1.40 times more likely to engage in VPA for less than 1 day (OR = 1.40; CI = 1.14–1.73; $p = 0.001$) and 1.3 times more likely to do so for less than 3 days (OR = 1.30; CI = 1.11–1.51; $p < 0.001$) compared to the Non-changed SES group. Similarly, for muscular strength activities, the odds of participation for less than 1 day (OR = 1.38; CI = 1.15–1.67; $p < 0.01$) and less than 3 days (OR = 1.31; CI = 1.11–1.54; $p = 0.001$) were higher in the lower SES group. However, no significant differences were observed between the two groups in participating in total PA less than 1 day (OR = 0.90; CI = 0.74–1.09; $p > 0.05$) and less than 3 days (OR =0.99; CI = 0.86–1.13; $p > 0.05$). Regarding SB, there were significant differences between the two groups. Adolescents in the Lower SES group had

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a 33 % lower likelihood of being classified as High SB (OR = 0.67; CI = 0.58–0.77; $p < 0.001$) and a 21% lower likelihood of being categorized as Medium SB (OR = 0.79; CI = 0.68–0.91; $p < 0.001$) compared to the Non-changed SES group. Concerning stress levels, adolescents in the Lower SES group were 2.3 times more likely to experience a very severe level of stress (OR = 2.27; CI = 1.67–3.09; $p < 0.001$) and 41% less likely to experience mild-level of stress (OR = 0.59; CI = 0.44–0.78; $p < 0.001$) than their counterparts in the Non-changed SES group.

Table 2. Multinominal logistic regression was used to predict the impact of perception of family SES on the PA, SB, and stress variables comparing the Lower SES group and the Non-changed SES group.

Variable		Lower SES Group (n = 3,072)						
		b	S.E	*Wald*	*p*	*Exp(b)*	*Exp(b)* 95% Confidence Intervals	
							Lower	Upper
Physical Activity								
Total PA								
	≤ 1 day	-0.11	0.10	1.19	0.275	0.90	0.74	1.09
	≤ 3 days	-0.02	0.07	0.05	0.825	0.99	0.86	1.13
	> 3 days	0[b]	.	.	.	.	.	.
VPA								
	≤ 1 day	0.34	0.11	10.19	.001***	1.40	1.14	1.73
	≤ 3 days	0.26	0.08	11.19	<.001***	1.30	1.11	1.51
	> 3 days	0[b]	.	.	.	.	.	.
Muscular Strength								
	≤ 1 day	0.32	0.10	11.32	<.001***	1.38	1.15	1.67
	≤ 3 days	0.27	0.08	10.61	.001***	1.31	1.11	1.54
	> 3 days	0[b]	.	.	.	.	.	.
SB								
	High	-0.40	0.07	30.51	<.001***	0.67	0.58	0.77
	Medium	-0.24	0.07	11.09	<.001***	0.79	0.68	0.91
	Low	0[b]	.	.	.	.	.	.
Stress								
	Very Severe	0.82	0.16	27.10	<.001***	2.27	1.67	3.09
	Severe	0.20	0.14	2.09	0.148	1.23	0.93	1.61
	Moderate	-0.09	0.14	0.46	0.496	0.91	0.70	1.19
	Mild	-0.53	0.15	13.08	<.001***	0.59	0.44	0.78
	Very Mild	0[b]	.	.	.	.	.	.

Reference group: Non-changed group; ***p<.001, **p<.01, *p<.05, OR: Odds Ratio, PA: Physical Activity, VPA: Vigorous Physical Activity; Total PA: This means participating in Moderate-intensity PA 60 minutes or more per day in the last 7 days; VPA: This means participating in Vigorous-intensity PA 20 minutes or more per day in the last 7 days; Muscular strength: This means the number of days participating in muscular strength activities in the last 7 days; PA was divided into 3 groups: ≤ 1day (0-1day), ≤ 3days (2-3days), > 3days (4-7days); SB: This means a total number of minutes spent sitting in the last 7 days; SB was divided into 3 groups: High: more than 1380 minutes, Medium: 920-1379 minutes, Low: less than 920 minutes. The analysis was adjusted by family SES and participants' academic performance.

Figure 1 presents the comparative analysis of average participation days in PA and the time spent in SB per week between the Lower SES group and the Non-changed SES group. In the Lower SES group, 1610 individuals participated in total PA for 1 day or less per week, 746 individuals participated for 3 days or less per week, 746 individuals participated for 3 days or less per week, and 716 individuals participated for more than 3 days per week. In contrast, the Non-changed SES group had 1641 participants engaging in total PA for 1 day or less per week, 772 participants for 3 days or less per week, and 659 participants for more than 3 days per week. for total PA. Regarding VPA, the Lower SES group had 666 individuals participating for 1 day or less per week, 795 individuals for 3 days or less per week, and 1611 individuals for more than 3 days per week. Conversely, the Non-changed SES group had 573 participants for 1 day or less per week, 776 participants for 3 days or less

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per week, and 1723 participants for more than 3 days per week in VPA. For muscular strength activities, the Lower SES group had 597 individuals participating for 1 day or less per week, 609 individuals for 3 days or less per week, and 1866 individuals for more than 3 days per week. The Non-changed SES group, on the other hand, had 499 participants for 1 day or less per week, 568 participants for 3 days or less per week, and 2005 participants for more than 3 days per week in muscular strength activities.

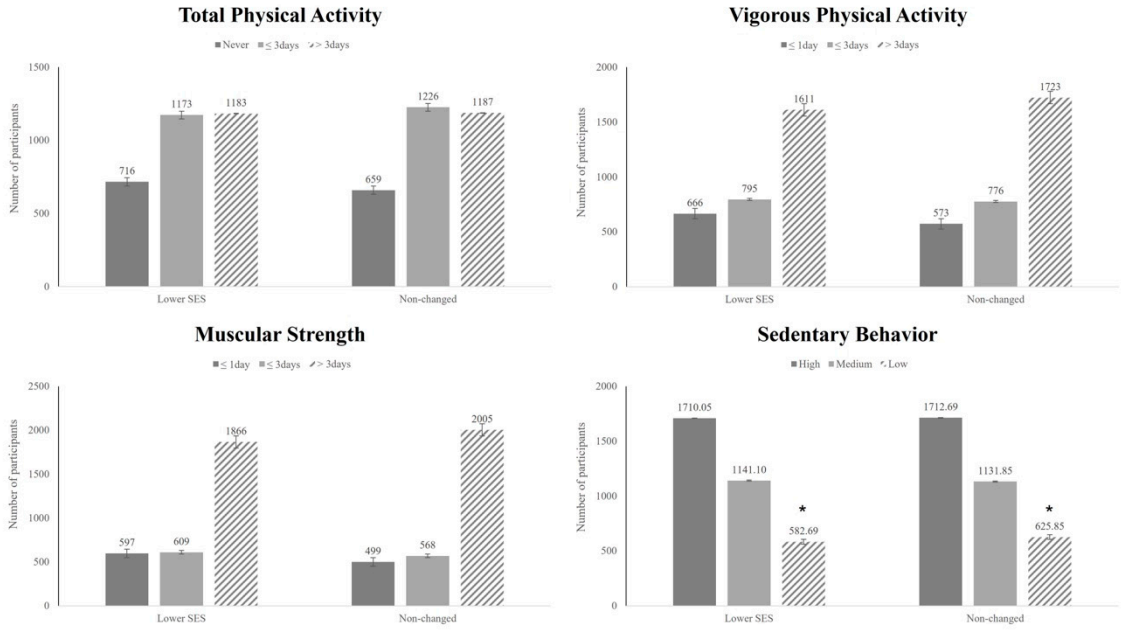

Figure 1. Comparison of average participating days of PA and spending time of SB during a week between the Lower SES group and the Non-changed SES group; SB was divided into 3 groups based on the average amount of time spent sitting per week to compare SB levels: High (≥ 1380 minutes), Medium (920–1379 minutes), and Low (< 920 minutes).

Overall, there were no significant differences in the number of participants engaging in total PA, VPA, and muscular strength activities between the two groups ($p > 0.05$). However, the Lower SES group exhibited a lower prevalence of VPA and muscular strength activities (i.e., ≤ 1 day and ≤ 3 days) compared to the Non-changed SES group. Notably, the total time spent in SB (minutes per week) showed a significant difference between the two groups only for Low SB ($p = 0.00$; 95% CI = -64.87–-21.44). The Lower SES group spent 582.69 ± 256.94 minutes per week in Low SB, while the Non-changed SES group spent 625.85 ± 237.48 minutes per week. For High SB, the Lower SES group spent 1710.05 ± 284.63 minutes per week, and for Medium SB, they spent 1141.10 ± 124.91 minutes per week. In comparison, the Non-changed SES group spent 1712.69 ± 284.46 minutes per week for High SB and 1131.85 ± 125.49 minutes per week for Medium SB.

Figure 2 illustrates a graphical depiction of the daily stress levels comparison between the Lower SES group and the Non-changed SES group. In the Lower SES group, the highest proportion of participants reported experiencing a moderate level of stress, accounting for 37% of the sample. This was followed by 30% of participants reporting a severe level of stress and 17% reporting a very severe level of stress. In contrast, in the Non-changed SES group, the majority of participants (43%) reported experiencing a moderate level of stress. Subsequently, 23% of participants reported a severe level of stress, and 21 reported a mild level of stress.

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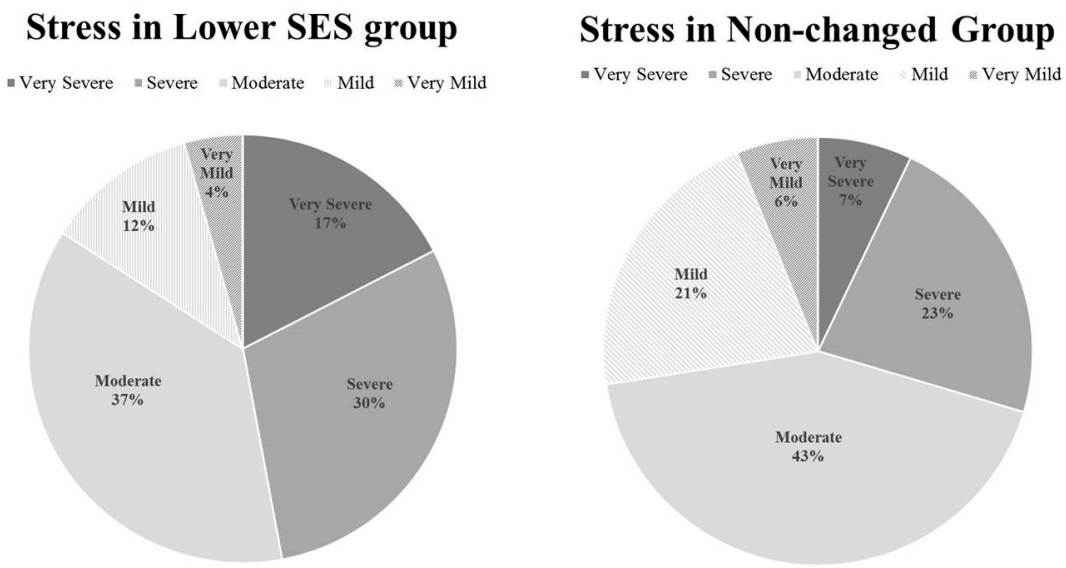

Figure 2. Comparison of stress level between Lower SES group and Non-changed SES group.

4. Discussion

Adequate PA plays a crucial role in promoting the healthy development of youth, encompassing various physical, mental, and social health benefits (Janssen & LeBlanc, 2010; Poitras et al., 2016). However, the outbreak of COVID-19 and subsequent restrictions have significantly limited opportunities for youth to engage in PA and exercise (Schmidt et al., 2020). These restrictions have also led to economic crises and recessions, impacting the family SES (Dang & Nguyen, 2021). Previous studies have highlighted the significant association between a family SES and health-related behaviors among young individuals (Bauman et al., 2012; Bauman et al., 2002; Gordon-Larsen et al., 2000). Considering the crucial interplay between external factors, family processes, and children's perceptions (Conger et al., 2010; Goodenow, 1993), it becomes essential to investigate the impact of children's perception of changes in family SES during COVID-19, regardless of actual SES, as it may serve as an essential determinant of youth's health-related behavior. However, there remains a dearth of research examining the associations of PA, SB, mental health, and perception of family SES among youth during the COVID-19 pandemic. Thus, this study aimed to examine the associations between PA, SB, and perceived stress among Korean adolescents, specifically focusing on the changes in the perception of family SES in the immediate aftermath of the COVID-19 outbreak in 2020.

The current study compared the association of PA, SB, and stress levels among adolescents in the Lower SES group and the Non-changed SES group based on changes in family SES perception. Our findings revealed that adolescents in the Lower SES group were less likely to participate in VPA and muscular strength activities compared to the Non-changed SES group ($p < 0.001$). Specifically, adolescents in the Lower SES group had 1.40 times higher odds of participating in VPA for less than 1 day ($p = 0.001$, OR = 1.15), 1.30 times higher odds of participating in VPA for less than 3 days ($p < 0.001$, OR = 1.30), 1.38 times higher odds of participating in muscular strength activities for less than 1 day ($p < 0.001$, OR = 1.38), and 1.31 times higher odds of participating in muscular strength activities for less than 3 days ($p = 0.001$, OR = 1.31) compared to the Non-changed SES group. However, there were no significant differences in total PA between the two groups ($p > 0.05$).

It is widely acknowledged that SES is closely linked to health outcomes (House, 2002), and numerous studies have explored the association between SES and health-related behaviors, particularly in relation to PA or SB (Grzywacz & Marks, 2001; R. E. Lee & Cubbin, 2002). In our study, we observed that the Lower SES group had a larger population of individuals in the low to middle classes of actual family SES (73.9%), while the Non-changed SES group had a higher representation in the middle to high classes (95.9%). Based on this observation, we propose that adolescents from low SES families were more likely to perceive changes in their family SES compared to those from

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high SES families during the COVID-19 pandemic. This perception of the economic downturn may have influenced reduced participation in VPA and muscular strength activities among adolescents in the lower SES group.

Although we accounted for actual family SES as a covariate for adjustment using categorical variables (i.e., high, middle-high, middle, middle-low, and low). It is essential for future research to incorporate more precise measures of parents' actual income levels. Additionally, our findings align with previous observations that adolescents with higher SES backgrounds tend to engage in more PA compared to their counterparts from lower SES backgrounds (Stalsberg & Pedersen, 2010). The lower levels of PA observed in adolescents from low SES families can be attributed to economic factors, including unfavorable neighborhood environments characterized by a lack of recreational areas and longer distances to access PA facilities (Gordon-Larsen, Nelson, Page, & Popkin, 2006). Given that the Lower SES group in our study primarily consisted of adolescents from the lower classes of SES and they perceived a decline in their family SES following the COVID-19 outbreak, it is reasonable to inform that these adolescents may have limited opportunities to participate in VPA and muscular strength activities, which often require parental financial support and access to sports facilities or academies.

Reciprocally, SB exhibited divergent outcomes when compared to PA, with significant discrepancies noted between the two cohorts. Our study focused on the examination of adolescents belonging to the Lower SES group, evaluating their weekly sitting duration (in minutes) relative to the Non-changed SES group. The data indicated a marked reduction of 40% in high SB ($p < 0.001$, OR = 0.67) and 25% in medium SB ($p < 0.001$, OR = 0.79) within the Lower SES group, in contrast to their peers in the Non-changed SES group. These findings presented a departure from prior research, which had previously established an inverse correlation between SB and SES in adolescents (Mielke, Brown, Nunes, Silva, & Hallal, 2017). One plausible interpretation for these observed SB patterns in our study is linked to the prevailing emphasis on academic excellence in South Korea, where education attainment holds substantial significance within the SES construct (Robinson, 1994; Son, 2004). Adolescents from high-SES households may exhibit an increased allocation of SB hours compared to their low-SES counterparts due to heightened involvement in private tutoring or after-school academies (J. Kim, 2013; J.-S. Kim & Bang, 2017; Park, 2009). In light of this empirical evidence and considering the perceived decline in family SES and lower level of academic performance among the Lower SES group in our study, it is conceivable that their perception of family SES might indirectly correlate with educational engagement and reduced SB. To ensure a comprehensive comprehension of the association observed, it is imperative to note that our analysis incorporated academic performance as a covariate, serving as a reflection of their educational involvement. Nonetheless, future investigations should account for other pertinent factors related to SB.

Furthermore, within our study, adolescents from the Lower SES group manifested a 2.27-fold higher likelihood of encountering very severe levels of stress level ($p < 0.001$, OR = 2.27) and a 1.23-fold higher likelihood of experiencing severe stress levels, though the latter did not attain statistical significance. These escalated stress levels among adolescents can be attributed to a multitude of factors, encompassing economic deterioration resulting in heightened financial burdens, adverse shifts in parental mental health, disruptions in marital interaction, and potential declines in parenting quality (Solantaus, Leinonen, & Punamäki, 2004). The imposition of economic constraints during the COVID-19 pandemic likely accentuated these stressors, disproportionately affecting the Lower SES group in our study, who perceived a decline in their family SES.

Adolescents, due to their sensitive and critical developmental stage, are particularly susceptible to the deleterious effects of chronic stress (Kong, So, & Jang, 2021). Notably, Kong et al. reported that stress could profoundly impact both the physical and mental health of individuals, contributing to conditions such as depression, suicide, sleep disturbances, cardiovascular disease, and compromised immune function (Kong et al., 2021). Concurrently, extant research has demonstrated the beneficial role of PA and exercise in promoting mental health (Khalsa, Hickey-Schultz, Cohen, Steiner, & Cope, 2012; O'Dougherty, Hearst, Syed, Kurzer, & Schmitz, 2012; Scott et al., 2012). Significantly, Kong et al. elucidated a noteworthy association between engaging in more than 20 minutes of VPA at least

three times per week and experiencing lower stress levels among adolescents (Kong et al., 2021). Similarly, Adams et al. emphasized the relationship between engaging in muscular strength activity and improved mental health (Adams, Moore, & Dye, 2007). Therefore, based on the existing evidence, augmenting involvement in VPA and muscular strength activities may serve as a potential strategy to ameliorate daily stress levels and enhance mental health, particularly among adolescents in the Lower SES group in our study. Nonetheless, it is essential to acknowledge that the findings generated inconsistent results, with the Lower SES group exhibiting a lower likelihood of experiencing mild-stress levels compared to the Non-changed SES group. Consequently, further investigations are necessary to explore additional pertinent factors that could influence stress levels among adolescents.

5. Strength and Limitations

The present study demonstrates several noteworthy strengths. Firstly, it represents the inaugural investigation to explore the association between PA, SB, and stress, particularly among age-matched adolescents, by categorizing the cohorts based on their perception of changes in family SES during the COVID-19 pandemic. Furthermore, our research yields novel findings by analyzing significant disparities in PA, SB, and stress among adolescents, taking into account their perception of family SES during the COVID-19 period. Nonetheless, the study is not without its limitations, which necessitate acknowledgment. First, the data on PA and SB were derived from self-reported responses, potentially leading to either underestimation or overestimation by individuals (Cerin et al., 2016). Moreover, the PA data were collected based on participation dates rather than precise time measurements, making direct comparison with the World Health Organization's (WHO) PA guidelines challenging. Additionally, the study did not incorporate the actual income level of parents due to the lack of accurate specifications for categorizing their income levels in the survey. Instead, we utilized an actual family SES variable as a covariate, which was categorized into the five hierarchical classes based on the survey data. To improve the validity of study results, future research should utilize reliable data on the actual family income levels as an SES measure.

6. Conclusion

In conclusion, the study has identified notable variations in levels of PA, SB, and stress levels among Korean adolescents, contingent on their perception of family SES in the aftermath of the COVID-19 outbreak in 2020. These findings offer valuable insights into the potential significance of promoting VPA and muscular strength activities among adolescents to bolster their physical and mental well-being during future pandemics. Based on the findings, we propose the implementation of targeted policies aimed at adolescents from low SES families or those susceptible to experiencing a decline in family SES following the future disease pandemic. Moreover, to enhance comprehension, it is crucial to gather further evidence from diverse countries worldwide to investigate the association between PA, SB, mental health, SES, and perception of SES among adolescents during disease pandemics.

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