



## Correlation Between Physical Activity and Screen Time With Sleep Duration: A Cohort Study Among Pre to Elementary School-Aged Children Before, During, and After The Covid-19 Pandemic

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### Abstract

**Background:** The COVID-19 pandemic has significantly altered children's daily routines, particularly increasing screen time, decreasing physical activity, and changing sleep duration, which may impact their physical and mental health. It is important to know how changes in physical activity and screen time can affect children's sleep duration before, during and after the COVID-19 pandemic. **Methods:** This study used a quantitative analytical observational cohort study method with 240 child samples aged 6–12 years in Semarang City. The sampling technique used simple random sampling. The research instrument used the SMALLQ<sup>®</sup> questionnaire. Data analysis techniques used normality tests, Spearman-Rank tests to determine correlations, and Kruskal-Wallis tests to compare data.

**Results:** The correlation between screen time and sleep duration was not statistically significant ( $p > 0.05$ ), while physical activity showed a significant positive correlation with sleep duration ( $r = 0.253$  on weekdays,  $r = 0.21$  weekly,  $p < 0.05$ ). Significant differences were found in screen time, physical activity, and sleep duration across the three periods ( $p < 0.001$ ), with increased screen time and decreased physical activity and sleep duration persisting post-pandemic.

**Conclusions:** The pandemic led to lasting increases in screen time and decreases in physical activity and sleep duration among children. Promoting healthier routines is essential to mitigate these impacts in the new normal era.

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## INTRODUCTION

The COVID-19 pandemic was declared a Public Health Emergency of International Concern (PHEIC) in December 2019, triggering social restrictions that have a major impact on health, development, changes in routines, and daily life such as increased screen time, reduced physical activity, unhealthy eating patterns and disrupted sleep patterns, especially in children (WHO, 2025). Sleep duration is one of the important aspects to maintain children's health. The recommended sleep duration for preschool children is 10-13 hours and 9-12 hours for children aged 5-12 years (Australia Government Department of Health and Aged Care, 2019; WHO, 2019, 2020). Due to the pandemic, globally 16% of children aged 5-17 years have decreased sleep duration and 49% do not meet sleep duration recommendations (Sharma et al., 2021). However, in Indonesia, the sleep duration of preschool-aged children remained stable above 10 hours/day and there was an increase in sleep duration in elementary school-aged children during the pandemic (Fauziah et al., 2022; Sekartini et al., 2024). Older children (>5 years old) are more likely to feel the impact of the pandemic by becoming less physically active, increasing sedentary behavior and screen time, and increasing sleep duration (Adibelli & Sümen, 2020; S. A. Moore et al., 2020).

Sleep duration is influenced by many things, such as physical activity and screen time. Physical activity plays an important role in maintaining physical and mental health and increasing self-confidence (Dhuli et al., 2022; Katzmarzyk et al., 2020; Rodriguez-Ayllon et al., 2019). Globally, there has been a decrease in the prevalence of physical activity in children from 46% before the pandemic to 19.5% during the pandemic restrictions (Chaabna et al., 2022). The prevalence of physical inactivity in Indonesia is 37.4% and 58% of them are children aged 10-14 years (MoH of Indonesia, 2024). Both preschool and primary school-aged children showed a decrease in moderate to vigorous intensity physical activity during the pandemic (Nopembri et al., 2023; Sekartini et al., 2024). Maintaining a physical activity routine of at least 60 minutes/day can improve and increase sleep duration and quality (Master

et al., 2019).

The pandemic, which has brought changes in many ways including the shift from offline learning to distance learning (online), has an impact on increasing the duration of screen time in children. Screen time exceeding 2 hours/day can lead to impaired cognitive function, language development, physical and mental health (Children's Hospital of Orange County (CHOC), 2024; Devi & Singh, 2023; Muppalla et al., 2023). A common complaint is computer vision syndrome (CVS), which has been proven to be the result of excessive use of digital media (Rochmayani & Cahyaningsih, 2021). During the pandemic, there was an increase in screen time of 0.89 hours/day in children aged 0-5 years and a doubling in children aged 0-21 years (Choi et al., 2023). The increase in screen time also occurred in preschool children in Indonesia, which amounted to 150% during the pandemic (Nopembri et al., 2023). Excessive screen time can disrupt sleep due to the influence of blue light exposure which disrupts melatonin secretion (Poza et al., 2020).

Changes in routines during the pandemic carried over to after the pandemic as shown in studies in Hong Kong and the UK where children became less physically active, increased sedentary behavior and screen time, changes in sleep duration, and lack of socialization (So et al., 2022; Walker et al., 2023). This study aims to determine the correlation between changes in duration of physical activity and duration of screen time on sleep duration of elementary school-age children (6-12 years old) in Semarang City before, during, and after the COVID-19 pandemic.

## METHODS

This research is an analytical observational quantitative study with a cohort study design. The data sources in this study come from primary data collected in March-April 2025 and secondary data comes from previous studies by Fauziah et al., 2022 that was conducted in 2019-2020. Secondary data contains data on duration of physical activity, duration of screen time, and sleep duration of pre-school children in the period before and during the COVID-19 pandemic. Meanwhile,

primary data collection was used to obtain data on duration of physical activity, duration of screen time, and sleep duration of elementary school-age children. The study population was all elementary school-aged children (6-12 years old) in Semarang City, totaling 125,702 children based on the Ministry of Primary and Secondary Education's Basic Education Data (DAPODIK). The research sample was obtained based on the calculation of the sample size for correlative-numerical analytical research by Dahlan, 2016.

$$n = \left[ \frac{(1,96 + 0,84)}{0,5 \ln \left( \frac{1 + 0,18}{1 - 0,18} \right)} \right]^2 + 3$$

The calculation results in a sample of 240 samples of children aged 6-12 years. The data collection technique used simple random sampling technique from the population that met the inclusion criteria, namely children aged 6-12 years who lived and attended both public and private schools in the Semarang City area, and had parents who lived together. Exclusion criteria included children who were not willing to be respondents, did not fill out the questionnaire completely, children who had physical and/or mental health problems, and were taking medications that affect sleep. Data collection was carried out by "door-to-door" or visiting the homes of the research sample, which had previously obtained children through DAPODIK, then conducting interviews with parents of children according to the contents of the questionnaire used. There was informed consent and instructions or explanations to respondents regarding the research.

The independent variables in this study are age of child, sex of child, height and weight of child, parent education level, duration of child physical activity and duration of child screen time. The research instruments used microtoise to measure height, digital scales to measure weight, and The Surveillance of digital Media hAbits in earLy chiLdhood Questionnaire (SMALLQ)<sup>®</sup> which has been translated into 18 languages including bahasa Indonesia to determine and measure the duration of physical activity, duration of screen time, and child sleep duration (Chia et al.,

2019). The collected data were subjected to normality test, univariate analysis, Spearman-Rank correlation test to analyze the correlation between variables, and Kruskal Wallis test to compare the groups before, during and after the pandemic. All statistical analyses were performed using Microsoft Excel software and IBM SPSS Statistics version 30. This study was approved by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Negeri Semarang with Number 419/KEPK/FK/KLE/2024.

## RESULT AND DISCUSSION

The results of data analysis of 240 children in the pre-pandemic period, 240 children during the pandemic period, and 240 children in the post-pandemic period showed that the proportion of boys (50.97%) was greater than girls (49.02%). The study samples in before and during pandemic periods were aged 3-5 years (preschool) and in after pandemic period were aged 6-12 years (elementary school). The proportion of samples in the period before and during the pandemic was more in children aged 4-5 years (42.08%) and samples in the period after the pandemic the proportion was more in children aged 9-12 years (23.88%).

Table 2 shows the average duration of screen time, duration of physical activity, and sleep duration of children in the 3 time periods. The average duration of screen time of preschool children is about 152 minutes or 2.53 hours. Meanwhile, the average duration of screen time of children aged 6-12 years was about 121 minutes or 2.03 hours. It is clear that for both children aged 3-5 years and 6-12 years, the duration of screen time exceeds the WHO recommended limit of maximum 2 hours/day. Duration of screen time for children increased significantly on weekdays and weekends during the pandemic. Then, there was a decrease in the period after the COVID-19 pandemic. Another study also showed similar results, namely an increase in duration of screen time in children of more than 60 minutes due to the pandemic (Choi et al., 2023). In addition, research in China showed the impact of each additional hour of screen time increased the risk of myopia progression by 1.26 times (Liu et al., 2021).

Duration of physical activity has

decreased from the period during the pandemic to after the pandemic on both weekdays and weekends. However, a significant decrease in duration of physical activity occurred on weekdays which decreased by more than 60 minutes (210.59 vs 192.69 vs 99.258), although it was still within the duration in accordance with WHO recommendations of at least 60 minutes/day. Other studies have also shown that after the pandemic the duration of children's physical activity has not increased or recovered as before the pandemic (Moore et al., 2024). Supported by evidence of daily steps in children aged 5-17 years, the average was 5441 steps before lockdown and became an average of 4616 steps during the lockdown situation (Singh et al., 2024).

Less noticeable changes occurred in children's sleep duration in the period before and during the COVID-19 pandemic with an increase in sleep duration only ranging from 0.27 - 10.77 minutes. However, in the period after the pandemic there was a significant decrease of more than 180 minutes in 3 time periods. In the period after the pandemic, sleep duration did not meet WHO recommendations of 10-13 hours/day for children aged <5 years and 9-12 hours for children aged 6-12 years.

Another study also showed an increase in sleep duration by 1.31 hours during the pandemic and a decrease in duration by 1.21 hours after the pandemic (So et al., 2022). During the pandemic, on weekdays children aged 6-13 years had 1.68 times higher odds of going to bed later and 2.33 times higher odds of waking up later and on weekends 1.91 times higher odds of waking up later than children aged 3-5 years (Kaditis et al., 2021).

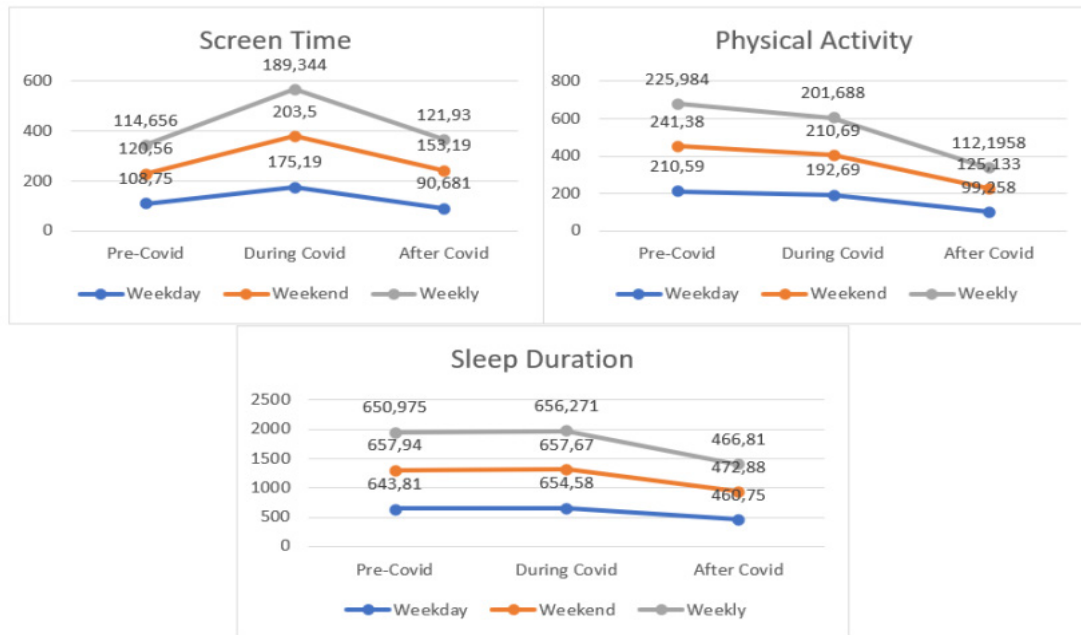
Then, a comparison of duration of screen time, duration of physical activity, and sleep duration in the time period before, during, and after the pandemic using a comparative test, namely Kruskal Wallis in Table 2. The Kruskal Wallis test was used to determine whether there were significant differences between the periods before, during, and after the pandemic based on the weekday, weekend, and weekly time periods. Duration of screen time, duration of physical activity, and sleep duration have significant test results ( $p < 0.05$ ) in weekday, weekend, and weekly periods. This shows that there is a differences in duration between the time period groups before, during, and after the pandemic in duration of screen time, duration of physical activity, and sleep duration.

**Table 1.** Distribution of Research Respondents

	Pre Covid	During Covid	After Covid	Total (%)
<b>Child characteristic</b>				
<b>Sex of child</b>				
Male	132	129	106	367 (50.97%)
Female	108	111	134	353 (49.02%)
<b>Age of child</b>				
2-3 years old	64	113	0	177 (24.58%)
4-5 years old	176	127	0	303 (42.08%)
6 - 8 years old	0	0	68	68 (9.44%)
9 - 12 years old	0	0	172	172 (23.88%)

**Table 2.** Average of Duration of Screen Time, Duration of Physical Activity, and Sleep Duration

	Pre COVID-19	During COVID-19	After COVID-19	Differences Kruskal Wallis	p-value
<b>Screen Time (minutes)</b>					
Weekday	108.75	175.19	90.68	43.44	<0.001
Weekend	120.56	203.5	153.19	40.57	<0.001
Weekly	114.65	189.34	121.93	37.43	<0.001
<b>Physical Activity (minutes)</b>					
Weekday	210.59	192.69	99.25	149.03	<0.001
Weekend	241.38	210.69	125.13	109.36	<0.001
Weekly	225.98	201.68	112.19	133.42	<0.001
<b>Sleep Duration (minutes)</b>					
Weekday	643.81	654.58	460.75	364.48	<0.001
Weekend	657.94	657.67	472.88	316.19	<0.001
Weekly	650.97	656.27	466.81	370.26	<0.001



**Figure 1.** Average Duration of Screen Time, Duration of Physical Activity, and Sleep Duration Before, During, and After the COVID-19 Pandemic

The relationship between duration of screen time with sleep duration and duration of physical activity with sleep duration is shown by the results of the bivariate test analysis using the Spearman Rank correlation test in Table 3. The results of this study show that duration of screen time is positively correlated with sleep duration ( $r = 0.01$  on weekdays,  $r = 0.047$  on weekends, and  $r = 0.002$  on weekdays) which means that the longer the duration of screen time, the longer the child's sleep duration. However, the statistical results showed  $p\text{ value} > 0.05$  which indicates that there is no relationship between screen time duration and

children's sleep duration and has a very weak relationship strength. The results of this study are not in line with many studies that show that duration of screen time is negatively correlated with sleep duration, which means that the longer the duration of device use, the shorter the sleep duration (Baby et al., 2021; dos Santos et al., 2024; Echevarria et al., 2023; G et al., 2024; Jain et al., 2025; Dr. M. A. Kumar, 2018; V. P. Kumar & Kiran, 2024; Twenge et al., 2019). Some factors that may cause the results of the correlation analysis of duration of screen time and children's sleep duration to be positively correlated include the type of content, location

when doing screen time, screen time, high physical activity during the day or evening so that they do not sleep during the day (Sourtiji et al., 2018).

The change in activity from preschool to elementary school brings many changes such as changes in sleep duration, duration of physical activity, and duration of screen time. Children aged 6-12 years are more prone to circadian rhythm sleep disorders due to the influence of the physical and social environment compared to preschool children (Reddy et al., 2019). Total sleep duration will be reduced and naps will be less frequent as influenced by school schedules and activities (Goel & Goel, 2024). In addition, at the age of 6-12 years, puberty has begun to occur. Hormonal changes such as melatonin secretion during puberty affect sleep architecture and timing (Goel & Goel, 2024). Melatonin is the main hormone regulating the sleep-wake cycle and peak melatonin production occurs between 8-10 years (Poza et al., 2020). Increased activity and academic pressure can affect melatonin production, one of which is due to gadget ownership to meet educational and entertainment needs.

Sleep and physical activity are two important factors for maintaining physical and mental health. The results of the correlation analysis between physical activity duration and sleep duration in this study show that there is a correlation between physical activity duration and sleep duration on weekdays and weekly. On weekday and weekly, the duration of physical activity and sleep duration are

positively correlated, i.e. the longer the duration of physical activity performed, the more sleep duration increases ( $r = 0.253$  on weekdays and  $r = 0.21$  on weekends,  $p < 0.05$ ). Meanwhile, the correlation results for the weekend time period did not show correlated results ( $p > 0.05$ ). This usually occurs because children are more active on weekdays where their schedules are structured such as going to school, doing sports in physical education (To et al., 2022).

Circadian rhythms are the body's internal regulation of human physiology, metabolism, and behavior (Reddy et al., 2019). Since during the pandemic there are social restrictions that lead to reduced exposure to sunlight, physical activity, changes in sleep patterns, and high exposure to artificial light from screens, this can disrupt eating rhythms. The "new normal" contributes to chronodisruptions in eating rhythms or imbalances in energy intake and expenditure due to changes in the time that should be used for sleep (light-dark cycle) being altered due to screen exposure (Boaventura et al., 2021). Exacerbated by physical activity patterns that have not returned to pre-pandemic conditions and insufficient sleep duration, the risk of overweight and obesity is high. Decreasing in sleep duration of about 65 minutes resulted in an increase in eating in the absence of hunger behavior by 16 kcal (Miller et al., 2019). Research in older children aged 13-15 years showed that sleep duration  $< 7$  hours was 1.9 times more likely to be overweight/obese and 2.1 times more likely to experience failure in school subjects (Litsfeldt et al., 2020).

**Table 3.** Correlation of Duration of Screen Time, Duration of Physical Activity, and Sleep Duration

Correlation between Screen Time, Physical Activity, and Sleep Duration	Correlation	
	Spearman	Sig.
<b>Correlation between Screen Time and Sleep Duration</b>		
Weekday: Screen Time vs Sleep Duration	0.010	0.878
Weekend: Screen Time vs Sleep Duration	0.047	0.469
Weekly: Screen Time vs Sleep Duration	0.002	0.980
<b>Correlation between Physical Activity and Sleep Duration</b>		
Weekday: Physical Activity vs Sleep Duration	0.253	$< 0.001$
Weekend: Physical Activity vs Sleep Duration	0.760	0.238
Weekly: Physical Activity vs Sleep Duration	0.210	0.001

The benefits of increasing the duration of physical activity and decreasing the duration of screen time have an impact on increasing the sleep duration and quality which is useful for physical and mental health such as reducing anxiety and depression (Master et al., 2019). Participation in sports, which means doing light, moderate or vigorous physical activity, has a positive relationship with increasing sleep duration and quality. When compared to older children, primary school-aged children are more active and do more physical activity and have low levels of sedentary behavior (Larrinaga-Undabarrena et al., 2023).

The strength of this study is the existence of the variable 'after the COVID-19 pandemic' which was then analyzed for comparison before, during, and after the COVID-19 pandemic, which no study has conducted a comparative test of 3 time periods before, during, and after the COVID-19 pandemic, especially in the Semarang City area. However, this study has limitations in that the sample used was only 240 respondents, which may not be generalizable to other cities. In addition, no Post-Hoc test was conducted to determine further differences between the two time periods and physical activity measurements were only based on parental reports. Future researchers are expected to conduct further analysis at each time period and be able to measure physical activity using accelerometers or other tools and be monitored directly.

## CONCLUSION

This study highlights the changes in duration of screen time, duration of physical activity, and children's sleep duration from before the pandemic, after the pandemic, to before the COVID-19 pandemic divided into weekday, weekend, and weekly time periods. The pandemic has caused an increase in the duration of screen time that is not in accordance with the recommendations, a decrease in the duration of physical activity, and also a decrease in sleep duration. These behaviors have had a negative impact until the period after the pandemic and there has been no change for the better. Reducing screen time behavior and increasing physical activity can increase the recommended sleep duration

to maintain physical and mental health and improve children's achievement. For future research, additional samples and data analysis can be carried out so that it can be generalized to other regions.

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