



Screen Time, Body Mass Index, and Hand Grip Strength Among 10–11-Year-Old Children in Urban Surabaya

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ABSTRACT

The increasing use of screen-based devices has changed children's daily activity patterns and may be related to their physical condition. This study analyzed the relationship between screen time (ST), nutritional status based on Body Mass Index (BMI), and physical fitness based on Hand Grip Strength (HGS) among children aged 10–11 years at SDN Simokerto V Surabaya. A quantitative descriptive-correlational design was used with purposive sampling involving 39 fourth-grade students. Screen time data were collected using a modified SCREENS-Q questionnaire, BMI was calculated from measurements, and HGS was measured using a hand grip dynamometer. Data were analyzed using Spearman Rho. The results showed that 85.7% of respondents had screen time exceeding two hours per day, 51.28% had normal BMI, and 61.5% had low hand grip strength. Spearman analysis found a significant negative relationship between ST and BMI ($r_s = -0.444$; $p = 0.005$) and between ST and HGS ($r_s = -0.432$; $p = 0.006$). These findings suggest that higher screen time was associated with lower BMI and lower muscular fitness in this sample.

Keyword: BMI, Hand Grip Strength, Screen Time, Sedentary Behavior

ABSTRAK

Peningkatan penggunaan perangkat berbasis layar telah mengubah pola aktivitas harian anak dan berpotensi berkaitan dengan kondisi fisik mereka. Penelitian ini menganalisis hubungan screen time (ST), status gizi berdasarkan Body Mass Index (BMI), dan kebugaran fisik berdasarkan Hand Grip Strength (HGS) pada anak usia 10–11 tahun di SDN Simokerto V Surabaya. Penelitian menggunakan desain kuantitatif deskriptif-korelasional dengan teknik purposive sampling terhadap 39 siswa kelas IV. Data ST diperoleh melalui kuesioner SCREENS-Q yang dimodifikasi, BMI dihitung dari pengukuran, sedangkan HGS diukur menggunakan hand grip dynamometer. Analisis data dilakukan menggunakan korelasi Spearman Rho. Hasil menunjukkan bahwa 85,7% responden memiliki ST lebih dari dua jam per hari, 51,28% memiliki BMI normal, dan 61,5% berada pada kategori HGS rendah. Analisis Spearman menemukan hubungan negatif yang signifikan antara ST dan BMI ($r_s = -0,444$; $p = 0,005$) serta antara ST dan HGS ($r_s = -0,432$; $p = 0,006$). Temuan ini menunjukkan bahwa ST yang lebih tinggi berkaitan dengan BMI dan kebugaran otot yang lebih rendah pada sampel penelitian.

Keyword: BMI, Kekuatan Otot Genggam, Screen Time, Gaya Hidup Sedentary



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1. Introduction

Children today grow up in an environment where screens are no longer occasional tools, but an integral part of everyday life. Smartphones, televisions, computers, tablets, and digital games have become embedded in how children learn, communicate, play, and spend their leisure time. This transformation has reshaped children's daily routines, shifting from physically active behaviours to more passive, screen-based activities. Such a shift is particularly important during childhood, as this developmental period plays a crucial role in shaping health-related behaviours, physical activity patterns, nutritional status, and physical fitness that may influence long-term health outcomes.

Sedentary behaviour refers to waking activities performed in a sitting, reclining, or lying position with low energy expenditure. Sedentary behaviour is any waking behaviour characterised by an energy expenditure of ≤ 1.5 metabolic equivalents of task (Tremblay et al., 2011). Prolonged sedentary behaviour is a public health concern because of its association with reduced physical activity and an increased risk of non-communicable diseases (Bull et al., 2020). In children, one of the most visible forms of sedentary behaviour is screen time, which refers to the duration spent using screen-based media such as television, computers, smartphones, and digital games. The concept of screen time developed alongside growing concerns about children's exposure to media technologies (Alper, 2014). Twenge and Campbell (2018) describe digital device use as an important marker of lifestyle change among children and adolescents.

The relationship between screen time and children's physical condition can be understood through several mechanisms, particularly the displacement effect. The screen exposure may replace time that could otherwise be used for active play, physical activity, sleep, and other health-promoting behaviours (Robinson et al., 2017). Similarly, Stiglic and Viner (2019) argue that excessive screen time is associated with various health outcomes in children, although the direction and strength of this relationship may vary with physical activity, sleep, diet, and social context. Therefore, screen time should not be understood merely as the use of digital devices, but as a behavioural pattern that may reduce children's opportunities for bodily movement and active participation in their physical environment.

Screen time is also relevant to nutritional status because it may influence the balance between energy intake and energy expenditure. Higher screen time was associated with an increased risk of overweight and obesity among children and adolescents (Haghjoo et al., 2022). The relationship between sedentary behaviour and adiposity in youth (Biddle et al., 2017). Body Mass Index (BMI) is commonly used to assess nutritional status by comparing body weight and height. However, in children, BMI must be interpreted carefully because age, sex, and growth processes influence body composition. Therefore, BMI is useful as a population-level indicator of nutritional status, but it should be interpreted alongside behavioural and developmental contexts.

Physical fitness is another important dimension of children's physical condition. Gupta (2023) defines physical fitness as the body's ability to perform daily activities effectively without excessive fatigue. One practical indicator of muscular fitness is Hand Grip Strength (HGS), which reflects isometric muscle strength and general muscle function. HGS can be used as a practical indicator of overall muscle function (Bohannon, 2019), while Osailan (2021) emphasising its association with functional capacity and general muscular strength. Recent studies further support the relevance of HGS in child health assessment. Abe et al. (2022) suggest that low hand grip strength in children may reflect broader health and functional risks, while Górnicka et al. (2020) showing that activity patterns, screen time, nutritional status, and muscle strength are interconnected among school-aged children.

The age group of 10–11 years is particularly important because it belongs to middle childhood, a developmental stage marked by the maturation of motor skills, coordination, balance, and muscular function. McDonough et al. (2020) explain that movement competence and physical activity experiences during this period support motor development, while Del Giudice (2014) describing middle childhood as a transitional phase before puberty, during which biological, cognitive, and social development begin to shape later outcomes. From the perspective of physical anthropology, the child's body is not only a biological object but also a product of interactions among growth, activity patterns, the environment, and sociocultural change.

Urban environments may further influence children's activity patterns. Gemmell et al. (2022) state that limited access to safe and supportive outdoor spaces can reduce children's opportunities for physical activity. Active play opportunities are related to children's movement behaviour and screen-based sedentary time (Carson et al., 2016). In densely populated urban areas, digital space may increasingly replace physical space as a site of entertainment, interaction, and leisure. Therefore, screen time among urban children should be understood as part of a broader transformation in children's activity culture, rather than merely as an individual habit.

Although previous studies have examined the associations among screen time, nutritional status, and physical fitness, research specifically examining the relationships between screen time, BMI, and HGS among elementary school children in a particular urban school context remains limited. This gap is important because local environmental conditions, school facilities, family habits, and access to digital devices may shape children's physical activity patterns and physical fitness differently. Therefore, this study aims to analyse the relationship between screen time, Body Mass Index, and Hand Grip Strength among children aged 10–11 years at SDN Simokerto V Surabaya. By placing screen time as an indicator of sedentary behaviour, BMI as an

indicator of nutritional status, and HGS as an indicator of physical fitness, this study seeks to provide empirical evidence on how children's bodies are shaped by digital activity patterns and urban environmental conditions.

2. Method

2.1. Research Design and Location

This study used a quantitative approach with a descriptive-correlational design. The design was selected to examine whether higher screen time was associated with children's nutritional status and physical fitness. The study was conducted at SDN Simokerto V Surabaya, located at Jl. Kenjeran IV No. 6, Simokerto District, Surabaya, East Java. The school was selected because it represents an elementary school in a dense urban environment with high access to digital technology, but with limited open spaces and sports facilities. The local context is relevant because urban density and limited physical space may shape children's daily activity patterns. Observations in the thesis indicated that many fourth-grade students had access to personal digital devices and that the school lacked an adequate sports field. This condition made the site appropriate for examining screen-based sedentary behaviour, nutritional status, and muscular fitness among school-aged children.

2.2. Population and Sample

The population consisted of all students of SDN Simokerto V Surabaya, totalling 203 students. The sample was selected using purposive sampling based on criteria relevant to the research objectives. The respondents were 39 fourth-grade students aged 10-11 years. This age group was chosen because it belongs to the middle childhood phase, which is relatively stable before the adolescent growth spurt and is important for motor and muscular development. Institutional permission from the school also limited data collection to fourth-grade students. Participation was conducted with ethical consideration. Because the respondents were children, parental or guardian consent was requested before data collection. Coordination was also carried out with the principal, class teacher, and accompanying teachers to ensure that the measurement procedures were safe and understandable for students.

2.3. Instruments and Data Collection

Screen time was measured using a modified SCREENS-Q (Screen-based Media Use Questionnaire). The questionnaire recorded the duration of children's screen-based activities during weekdays and weekends, including watching content, playing games, using social media, and doing school assignments. The modification was intended to make the instrument understandable to children and parents in the local context without altering its primary purpose of measuring screen-based media use. BMI was calculated from measurements. Body height was measured with a stadiometer while the student stood upright without footwear, and body weight was measured with a digital scale while the student wore light clothing and stood without footwear. BMI was calculated using the formula weight in kilograms divided by height in meters squared. The BMI results were interpreted according to age- and sex-specific references for children. Hand grip strength was measured using a hand grip dynamometer on the dominant hand. The measurement was used to represent muscular fitness and functional strength. All field data were recorded on measurement forms and then checked for completeness before coding and statistical analysis.

2.4. Data Analysis

Data were organised, coded, cleaned, and tabulated before analysis. Screen time was categorised into two groups based on commonly used recommendations: ≤ 2 hours/day and > 2 hours/day. Descriptive statistics were used to present respondent characteristics, BMI, HGS, and ST. The normality of the data was assessed using the Shapiro–Wilk test to determine the appropriate statistical procedure for correlation analysis (Table 1). BMI was not normally distributed ($p = 0.000$), while Hand Grip Strength (HGS) and screen time (ST) were normally distributed, with significance values of 0.057 and 0.063, respectively. Since one of the main variables did not meet the assumption of normality, the correlation analysis was performed using Spearman's Rho, a nonparametric statistic suitable for non-normally distributed data.

Table 1. Shapiro-Wilk Normality Test

Variable	Shapiro-Wilk Sig.
BMI	0.000
HGS	0.057
ST	0.063

The results of the Spearman's Rho test (Table 2) showed a statistically significant negative correlation between screen time and BMI ($r_s = -0.444$; $p = 0.005$), indicating that higher screen time was associated with lower BMI values among the respondents. A statistically significant negative correlation was also found between screen time and HGS ($r_s = -0.432$; $p = 0.006$), suggesting that children with higher screen time tended to have lower hand grip strength. Both correlations were classified as moderate in strength, indicating that although screen time was significantly associated with BMI and HGS, these physical indicators may also be influenced by other factors, such as physical activity level, dietary patterns, sleep duration, growth dynamics, and the broader urban environment.

3. Result and Discussion

3.1. BMI, screen time, and hand grip strength distribution

Descriptive statistics showed considerable variability, including the three main variables (Table 2). BMI ranged from 13 to 27, with a mean of 17.38 and a standard deviation of 3.978. HGS ranged from 5 to 20 kg, with a mean of 11.36 kg and a standard deviation of 3.681. Screen time ranged from 2 to 13 hours per day, with a mean of 6.67 hours and a standard deviation of 3.231. The average screen time was far above the commonly recommended limit of two hours per day for recreational screen use among school-aged children.

Table 2. Descriptive statistics of research variables.

Variable	N	Min	Max	Mean	SD
BMI	39	13	27	17.38	3.978
Hand Grip Strength (kg)	39	5	20	11.36	3.681
Screen Time (hours/day)	39	2	13	6.67	3.231

The BMI distribution (Table 3) indicated that more than half of the respondents were in the normal category. Nevertheless, a substantial proportion of students were classified as overweight or obese. This finding indicates that respondents' nutritional status was heterogeneous, with both undernutrition and overnutrition present within the same school population. Most respondents reported screen time above two hours per day (Table 3). The distribution showed that 85.7% of students exceeded the recommended duration, while only 14.3% were within the recommended limit. This indicates that screen-based activity had become a dominant part of children's daily routines in the study setting. The HGS distribution (Table 3) showed that 61.5% of respondents were in the low category, 38.5% in the normal category, and none in the high category. This pattern suggests that the sample's muscular fitness was not optimal.

Table 3. Distribution of Body Mass Index

Variable Category	Frequency (n)	Percentage (%)
BMI		
Underweight	4	10.26
Normal	20	51.28
Overweight	7	17.95
Obesity	8	20.51
Screen Time		
<2 hours/day	6	14.3
>2 hours/day	36	85.7
HGS		
Low	24	61.5
Normal	15	38.5
High	0	0.0

3.2. Relationship between Screen Time and BMI

Table 4. Spearman's Rho Corellation Test

Variable	N	Rs	Sig.
ST-BMI	39	-0.444	0.005
ST-HGS	39	-0.432	0.006

The findings of this study indicate that ST was significantly associated with both BMI and HGS among children aged 10–11 years at SDN Simokerto V Surabaya (Table 4). The Spearman's Rho correlation analysis showed a statistically significant negative relationship between ST and BMI ($r_s = -0.444$; $p = 0.005$), indicating that higher screen time was associated with lower BMI in this sample. The strength of this association was moderate, suggesting that screen time was related to BMI but did not fully account for variations in nutritional status among respondents. This finding does not entirely support the common assumption that higher screen time is always associated with higher BMI. Instead, it should be interpreted carefully as a correlational result within a specific sample and local context. Theoretically, screen time is often positioned as an obesogenic behaviour because it may reduce opportunities for physical activity, displace sleep, and increase energy intake through snacking or exposure to food marketing during media use. However, the present finding suggests that the relationship between screen time and BMI in children is not always linear.

Based on the correlation coefficient, the estimated effect size indicated that approximately 19.7% of BMI variation was related to screen time variation, while the remaining 80.3% may be explained by other factors not measured in this study, such as dietary intake, physical activity level, sleep duration, local environmental conditions, and biological growth during middle childhood. Therefore, this significant association should not be interpreted as evidence of a causal relationship or as an indication that screen time alone determines BMI. Rather, it indicates that children's nutritional status is shaped by multiple behavioural, biological, and contextual factors that interact with one another.

The negative association between ST and BMI may also reflect the limitation of BMI as a single indicator of children's physical condition. BMI is useful as a population-level indicator of nutritional status, but it does not distinguish between fat mass and lean mass. Thus, lower BMI among children with higher screen time does not necessarily indicate a healthier body composition; it may instead reflect lower fat-free mass, lower lean mass, or less optimal muscle development. This interpretation is relevant because a large proportion of respondents in this study also had low hand grip strength. During middle childhood, changes in BMI may reflect not only energy balance but also normal variations in growth, body composition, and muscular development. Therefore, the lower BMI values observed among children with higher screen time should not be interpreted simply as lower adiposity, but rather as a possible indication of differences in body composition that warrant further examination with more specific indicators.

The descriptive findings also show that high screen time was a dominant pattern among respondents. Most children exceeded the recommended screen time duration for school-aged children, indicating that screen-based activities had become a common part of their daily routines. This pattern reflects the broader transformation of childhood in the digital era, in which smartphones and other screen-based devices function not only as tools for entertainment but also as media for learning, communication, and peer interaction. Data on device ownership suggest that many students had access to personal digital devices from an early age, making it difficult to separate screen-based activities from their everyday social and academic lives. In an urban context such as Simokerto, this condition may be reinforced by environmental factors. The school and surrounding neighbourhood are characterised by densely built-up areas and limited open spaces for physical activity. The absence of adequate school fields and the limited availability of safe outdoor play areas may reduce opportunities for children to engage in spontaneous physical play. Consequently, digital space may increasingly replace physical space as a site of leisure, entertainment, and social interaction. Therefore, screen time in this study should be understood not merely as individual behaviour, but also as part of a broader urban lifestyle shaped by access to technology, limited play space, and changing patterns of childhood socialisation.

The Spearman's Rho test showed a statistically significant negative relationship between screen time and HGS ($r_s = -0.432$; $p = 0.006$), meaning that higher screen time tended to be associated with lower hand grip strength. This relationship was also moderate in strength, indicating that screen time was associated with muscular fitness but was not the only factor influencing HGS. The estimated effect size indicated that approximately 18.7% of the variation in HGS was attributable to screen time, while the remaining variation may be influenced by physical activity, playing habits, nutritional status, muscle development, and growth-related factors. This

finding supports the displacement effect, in which time spent using screen-based media may reduce opportunities for active play, physical movement, and activities that provide mechanical and muscular stimulation. In the context of SDN Simokerto V Surabaya, limited school facilities and dense urban surroundings may further restrict outdoor physical activities, making children more likely to engage in digital games and other online media for entertainment and social interaction. When physical play is increasingly replaced by sedentary screen-based activities performed while sitting, the musculoskeletal stimuli required for optimal development during middle childhood may be reduced.

The dominance of low HGS in the sample is therefore important because hand grip strength is not only a measure of hand muscle capacity but also a practical indicator of general muscular function and physical fitness. In this study, many respondents were categorised as having low handgrip strength, while none were in the high-strength category. This pattern suggests that the respondents' physical fitness may not be developing optimally. Screen-based activities, particularly smartphone use and digital gaming, are generally performed in a sitting position and involve repetitive, low-intensity movements of the fingers and wrists. Although these activities require fine motor engagement, they do not provide sufficient whole-body movement or resistance stimulus to support broader muscular development. Prolonged static hand positions may also increase low-level muscle contraction in the wrist and fingers, potentially contributing to muscle fatigue without improving overall muscular strength. Consequently, the relationship between high screen time and low HGS may be more relevant for understanding the physical consequences of sedentary behaviour than the relationship between screen time and BMI alone. This interpretation is supported by previous literature emphasising that hand grip strength is a health-related indicator in children and that low HGS during childhood may persist into adulthood without appropriate physical exercise strategies.

The pattern of digital activity further strengthens this interpretation. Watching digital content and playing online games were major contributors to total screen time. Watching content represents a relatively passive form of media use, while online gaming represents a more participatory but still sedentary activity. The dominance of online gaming suggests that children's peer interaction increasingly occurs in digital spaces rather than through direct physical play. Although digital games may support communication and social connection, they are usually performed with minimal physical movement. This shift is particularly relevant during middle childhood, when active play is essential for developing motor coordination, balance, muscle strength, and functional movement. Social media use appeared to be less dominant than watching and gaming, which is consistent with the developmental characteristics of children aged 10–11 years, whose social needs are still more strongly oriented toward play, exploration, and peer engagement than toward identity construction through social media. Meanwhile, screen use for school assignments was present but did not dominate overall screen time, suggesting that recreational use of digital devices contributed more substantially to children's screen exposure than educational use.

The results show that screen time among children in this study should be interpreted as both an indicator of sedentary behaviour and a marker of digital childhood in an urban environment. The significant negative correlation between screen time and BMI warrants cautious interpretation, as BMI alone cannot capture body composition or distinguish fat mass from lean mass. In contrast, the significant negative correlation between screen time and HGS provides stronger evidence that excessive screen exposure may be related to reduced muscular fitness. These findings highlight that the physical consequences of screen-based sedentary behaviour may be more evident in functional indicators, such as handgrip strength, than in BMI alone. From a physical anthropology perspective, children's bodies are shaped not only by biological growth but also by daily habits, technological exposure, physical space, and sociocultural change. Therefore, interventions aimed at reducing the negative impact of high screen time should not focus only on limiting device use, but also on improving opportunities for active play, strengthening school-based physical activity, increasing parental awareness, and creating urban environments that support children's movement and musculoskeletal development.

4. Conclusion

This study found that screen time was a dominant part of daily activity among children aged 10–11 years at SDN Simokerto V Surabaya. Most respondents exceeded 2 hours of screen time per day, and most had low handgrip strength. Spearman's Rho analysis showed significant relationships between ST and BMI and between ST and HGS. The moderate strength of these correlations indicates that screen time was associated with children's physical condition, but was not the only determining factor. The relationship between ST and BMI should be interpreted with caution because BMI does not distinguish between fat and lean mass and is strongly influenced by age, sex, and growth during middle childhood. The relationship between ST and HGS

suggests that high screen exposure may be more strongly associated with muscular fitness and functional strength. Future studies should include dietary intake, sleep quality, physical activity, body composition, and biological maturation to provide a more complete explanation of the relationship between digital behaviour and children's physical condition.

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6. Conflict of Interest

The authors declare no conflict of interest.

References

- Abe, T., Thiebaud, R. S., Ozaki, H., Yamasaki, S., & Loenneke, J. P. (2022). Children with low handgrip strength: A narrative review of possible exercise strategies to improve its development. *Children*, 9(11), Article 1616. <https://doi.org/10.3390/CHILDREN9111616>
- Alper, M. (2014). *Digital youth with disabilities*. <https://doi.org/10.7551/MITPRESS/10259.001.0001>
- American Academy of Pediatrics. (2016). Media and young minds. *Pediatrics*, 138(5). <https://doi.org/10.1542/PEDS.2016-2591>
- Biddle, S. J. H., García Bengoechea, E., & Wiesner, G. (2017). Sedentary behaviour and adiposity in youth: A systematic review of reviews and analysis of causality. *Journal of Behavioral Nutrition and Physical Activity*. <https://doi.org/10.1186/s12966-017-0497-8>
- Bohannon, R. W. (2019). Considerations and practical options for measuring muscle strength: A narrative review. *BioMed Research International*, 2019, Article 8194537. <https://doi.org/10.1155/2019/8194537>
- Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., Dipietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., . . . Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, 54(24), 1451–1462. <https://doi.org/10.1136/bjsports-2020-102955>
- Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: Complex or simple? Research case examples. *Journal of Research in Nursing*, 25(8), 652–661. <https://doi.org/10.1177/1744987120927206>
- Carson, V., Hunter, S., Kuzik, N., Gray, C. E., Poitras, V. J., Chaput, J.-P., Saunders, T. J., Katzmarzyk, P. T., Okely, A. D., Gorber, S. C., Kho, M. E., Sampson, M., Lee, H., & Tremblay, M. S. (2016). Systematic review of sedentary behaviour and health indicators in school-aged children and youth: An update. *Applied Physiology, Nutrition, and Metabolism*, 41(6), S240–S265. <https://doi.org/10.1139/APNM-2015-0630>
- Centers for Disease Control and Prevention. (2024). *Child and teen BMI calculator*. <https://www.cdc.gov/bmi/child-teen-calculator/index.html>
- Del Giudice, M. (2014). Middle childhood: An evolutionary-developmental synthesis. *Child Development Perspectives*, 8(4), 193–200. <https://doi.org/10.1111/CDEP.12084>
- Dong, X., Ding, L., Zhang, R., Ding, M., Wang, B., & Yi, X. (2021). Physical activity, screen-based sedentary behavior and physical fitness in Chinese adolescents: A cross-sectional study. *Frontiers in Pediatrics*, 9, Article 722079. <https://doi.org/10.3389/fped.2021.722079>
- Edelson, L. R., Mathias, K. C., Fulgoni, V. L., & Karagounis, L. G. (2016). Screen-based sedentary behavior and associations with functional strength in 6–15 year-old children in the United States. *BMC Public Health*, 16, Article 116. <https://doi.org/10.1186/s12889-016-2791-9>
- Gemmell, E., Ramsden, R., Brussoni, M., & Brauer, M. (2022). Influence of neighborhood built environments on the outdoor free play of young children: A systematic, mixed-studies review and thematic synthesis. *Journal of Urban Health*, 100(1), 118–150. <https://doi.org/10.1007/S11524-022-00696-6>

- Górnicka, M., Hamulka, J., Wadolowska, L., Kowalkowska, J., Kostyra, E., Tomaszewska, M., Czeczelewski, J., & Bronkowska, M. (2020). Activity-inactivity patterns, screen time, and physical activity: The association with overweight, central obesity and muscle strength in Polish teenagers. Report from the ABC of Healthy Eating Study. *International Journal of Environmental Research and Public Health*, 17(21), 1–21. <https://doi.org/10.3390/IJERPH17217842>
- Gupta, R. (2023). National guidelines for physical activity. In *Physical activity and public health practice* (pp. 195–209). CRC Press.
- Haghjoo, P., Siri, G., Soleimani, E., Farhangi, M. A., & Alesaeidi, S. (2022). Screen time increases overweight and obesity risk among adolescents: A systematic review and dose-response meta-analysis. *BMC Primary Care*, 23(1). <https://doi.org/10.1186/S12875-022-01761-4>
- Maria, I., & Puteh, M.-O. (2025). Screen time vs. active play: How digital exposure impacts the acquisition of fundamental motor skills in early childhood. *Al-Athfal: Jurnal Pendidikan Anak*, 11(1), 153–170. <https://doi.org/10.14421/al-athfal.2025.111-10>
- McDonough, D. J., Liu, W., & Gao, Z. (2020). Effects of physical activity on children's motor skill development: A systematic review of randomized controlled trials. *BioMed Research International*, 2020(1), Article 8160756. <https://doi.org/10.1155/2020/8160756>
- Osailan, A. (2021). The relationship between smartphone usage duration (using smartphone's ability to monitor screen time) with hand-grip and pinch-grip strength among young people: An observational study. *BMC Musculoskeletal Disorders*, 22(1). <https://doi.org/10.1186/S12891-021-04054-6>
- Potter, M., Spence, J. C., Boule, N., Stearns, J. A., & Carson, V. (2018). Behavior tracking and 3-year longitudinal associations between physical activity, screen time, and fitness among young children. *Pediatric Exercise Science*, 30(1), 132–141. <https://doi.org/10.1123/pes.2016-0239>
- Riya Gupta, S. V. (2023). National guidelines for physical activity. *Physical Activity and Public Health Practice*, 195–209. <https://doi.org/10.1201/b11718-16>
- Robinson, T. N., Banda, J. A., Hale, L., Lu, A. S., Fleming-Milici, F., Calvert, S. L., & Wartella, E. (2017). Screen media exposure and obesity in children and adolescents. *Pediatrics*, 140(Suppl. 2), S97–S101. <https://doi.org/10.1542/PEDS.2016-1758K>
- Stiglic, N., & Viner, R. M. (2019). Effects of screentime on the health and well-being of children and adolescents: A systematic review of reviews. *BMJ Open*, 9(1), Article e023191. <https://doi.org/10.1136/BMJOPEN-2018-023191>
- Tremblay, M. S., Leblanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., Goldfield, G., & Gorber, S. C. (2011). *Systematic review of sedentary behaviour and health indicators in school-aged children and youth*. <https://doi.org/10.1186/1479-5868-8-98>
- Twenge, J. M., & Campbell, W. K. (2018). Associations between screen time and lower psychological well-being among children and adolescents: Evidence from a population-based study. *Preventive Medicine Reports*, 12, 271–283. <https://doi.org/10.1016/J.PMEDR.2018.10.003>
- Wilhite, K., Booker, B., Huang, B., Antczak, D., Corbett, L., Parker, P., Noetel, M., Rissel, C., Lonsdale, C., & Sanders, T. (2023). Combinations of physical activity, sedentary behavior, and sleep duration and their associations with physical, psychological, and educational outcomes in children and adolescents: A systematic review. *American Journal of Epidemiology*, 192(4), 665–679. <https://doi.org/10.1093/aje/kwac212>