

Combined Effects of Physical Inactivity and Screen Time on Cardiorespiratory Fitness among Adolescents in Karachi: An Analytical Study

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Abstract

Background

Cardiorespiratory fitness (CRF) is a key indicator of cardiovascular and overall health status. Lifestyle behaviors, physical inactivity, and excessive screen time significantly affect CRF among adolescents. This study aimed to examine the association between excessive screen time and physical activity levels, and to determine their relationship with cardiorespiratory fitness among healthy adolescents.

Methods

This analytical study included 276 adolescents (boys and girls) aged 10–16 years from Karachi, Pakistan. Screen time and physical activity levels were assessed using a modified Physical Activity Questionnaire for Older Children (PAQ-C). Cardiorespiratory fitness was evaluated using a 3-minute walk test. Data were analyzed using IBM SPSS Statistics version 23.0. The Pearson Chi-Square test was used to determine the association between physical activity levels and screen time. Multiple regression analysis was done for relationships between physical activity, screen time, and CRF parameters. Statistical significance was set at $p < 0.05$.

Results

Most participants were female (64.5%). Physical activity scores showed significant associations with screen time ($p < 0.01$), oxygen saturation ($p < 0.04$), and exertion levels ($p < 0.01$). The 3-minute walk test demonstrated significant increases in systolic blood pressure, diastolic blood pressure, rate of perceived exertion, and heart rate (all $p < 0.01$) from pre- to post-test. Physical activity scores correlated positively with BMI, systolic blood pressure, and oxygen saturation. Screen time showed direct relationships with BMI, diastolic blood pressure, heart rate, and oxygen saturation. Distance covered during the test correlated with systolic blood pressure, rate of perceived exertion, heart rate, and oxygen saturation.

Conclusion

Physical inactivity demonstrated a positive correlation with screen time. The observed changes in cardiorespiratory parameters suggest that excessive screen time may negatively impact overall physical fitness among adolescents.

Background

Physical inactivity among adolescents is an emerging global public health concern, serving as an important predictor of future health problems. Research has linked physical inactivity with numerous non-communicable diseases (NCDs) in adolescents, including obesity, type II diabetes mellitus,

hypertension, and cardiovascular diseases (CVD) [1]. Excessive screen time has emerged as a leading contributor to physical inactivity among adolescents, resulting in various adverse health outcomes [2].

Cardiorespiratory fitness (CRF) is a significant indicator of cardiovascular and physical health status. Recent literature reports that decreased physical activity directly correlates with reduced CRF levels [3]. Furthermore, low CRF levels are recognized as independent risk factors for both morbidity and mortality among adolescents [4].

The management of cardiorespiratory diseases is very challenging for healthcare systems due to the significant financial burden imposed on national economies. Recent estimates indicate that cardiorespiratory care costs 54 billion USD globally, with approximately \$31 billion funded by governments in both high- and middle-income countries [5]. Healthcare costs vary significantly across countries, reaching \$2 billion USD annually in the United States, \$3.6 billion USD in Canada, and €282 billion for the 28 European Union countries [6]. The World Economic Forum and Harvard School of Public Health predict that Asia will experience approximately \$2.17 trillion in economic losses due to CVD between 2012 and 2030 [7].

Cardiovascular disease remains the leading cause of death worldwide, accounting for 31.8% of all deaths and 14.7% of Disability Adjusted Life Years (DALYs) in 2017 [8]. According to Global Burden of Disease (GBD) findings, South Asia contributes the largest CVD burden, estimated at approximately 422 million cases globally [9].

Recent observations indicate that sedentary behavior among adolescents is increasing in developing countries due to technological advancement, which significantly affects CRF levels. It has also been reported that among healthy individuals, CRF serves as a reliable prognostic indicator [10].

This study aimed to examine the association between excessive screen time and physical activity levels using the modified PAQ-C questionnaire, and to determine its relationship with CRF through submaximal exercise testing using a 3-minute walk test among healthy adolescents in urban Karachi, Pakistan.

Materials and Methods

Study Design and Participants

This analytical cross-sectional study was conducted in schools across different urban areas of Karachi, Pakistan, using non-probability purposive sampling.

This study included participants aged 10–16 years of both genders. Patients with congenital cardiac birth defects or a history of cardiac surgery were excluded. The purpose of the study was explained to all participants who met the inclusion criteria, and enrollment occurred following written informed consent from parents and verbal assent from adolescent participants.

Sample Size

The sample size ($n = 276$) was calculated using OpenEpi software with a 95% confidence interval (CI), 5% margin of error, and an assumed correlation of 29% between screen time and VO_2 max [11]. Power analysis was conducted using PASS 2021 to justify a sample size of 276 participants. Based on multiple linear regression analysis with a 95% confidence interval, the calculated power was 83.53%.

Initial assessment

A detailed explanation of the study procedures, including cardiorespiratory fitness (CRF) testing, was provided to all eligible participants. Those who showed interest and met the predefined inclusion criteria were enrolled in the study after providing written informed consent. Participants were recruited from the schools across different urban areas of Karachi. Baseline anthropometric characteristics were assessed by the investigator and included body mass index (BMI), calculated from height (cm) and weight (kg).

Data collection

Following the assessment of anthropometric characteristics, physical activity and screen time were assessed using the standardized questionnaire modified Physical Activity Questionnaire for Children (PAQ-C). Then the investigator recorded the participants' baseline anthropometric measurements. Height was measured in centimeters using a measuring tape, with each participant standing barefoot in an upright position with their back supported against a wall. Weight was measured in kilograms using a weighing scale, with participants standing barefoot on the scale without any accessories or additional items.

Before commencing the cardiorespiratory fitness (CRF) test, baseline measurements of blood pressure, heart rate, oxygen saturation (SpO_2), and perceived exertion were recorded. Blood pressure was measured using a manual sphygmomanometer, while heart rate and oxygen saturation were assessed using a pulse oximeter. Perceived exertion was evaluated using the standardized Borg Rate of Perceived Exertion (RPE) Scale.

For the CRF assessment, participants were instructed to walk along a 30-meter corridor, from one end to the other, at their normal comfortable pace for 3 minutes. The stopwatch was started at the beginning of the test, and participants were instructed to continue walking for the entire 3-minute period.

To assess changes during the test, blood pressure, heart rate, oxygen saturation, and perceived exertion were recorded at baseline and after the test for comparison of the participants' CRF fitness.

Outcome measure

Outcome measure

An English-language version of the Modified Physical Activity Questionnaire for Older Children (Modified PAQ-C) was used to assess physical activity levels among adolescents. The questionnaire was originally developed by Kowalski et al. and subsequently modified by Kolimechkov et al. [11] The questionnaire included nine items evaluating time spent on various physical activities, along with additional items assessing screen-based activities. Questions were structured separately for weekdays and weekends. A self-administered, paper format was used for data collection.

The questionnaire had three components. The first component, completed by the principal investigator, included demographic information such as weight (kg) and height (cm). Weight was measured using a manual weight scale, while height was measured using a height chart. Participants completed the second component, which consisted of the modified PAQ-C questionnaire containing nine standard items about time spent in physical activities, including walking, cycling, running, swimming, football, badminton, volleyball, and basketball. Additional questions assessed screen time activities such as watching Netflix and playing video games, with separate assessments for weekdays and weekends.

Cardiorespiratory Fitness Assessment

The third part of the questionnaire was the CRF testing, evaluated by using the 3-minute walk test. It was completed by the principal investigator. This test was selected because it was simple, time-efficient, and feasible for administration in school settings with limited space and resources, and provided a reliable estimate of cardiorespiratory fitness in adolescents.

Initially, baseline measurements were obtained for blood pressure, oxygen saturation, heart rate, and exertion levels. Blood pressure was measured using a digital BP apparatus (Model No: HEM-7120-E), while oxygen saturation and heart rate were assessed using a pulse oximeter (Model No: A3-10). Exertion levels were measured by using the Borg Rate of Perceived Exertion Scale.

Participants were then instructed to walk along a 30-meter corridor at a normal pace for three minutes. During the walk, the principal investigator counted the number of laps completed to calculate the total distance covered. After the three-minute walk, post-exercise measurements of blood pressure, oxygen saturation, heart rate, and exertion levels for compared by using the same apparatus.

Statistical analysis

Data were stored and analyzed using IBM-SPSS version 23.0. Comparison of cardiorespiratory parameters from pre- to post-exercise was conducted using paired sample t-tests. Pearson chi-square tests examined associations between screen time, physical activity levels, and CRF parameters. Statistical significance was set at $p < 0.05$ for Pearson chi-square analysis. Multiple regression analysis assessed relationships among PAQ-C scores, blood pressure measurements, exertion levels, heart rate, oxygen saturation, and distance covered during the three-minute walk. Beta coefficients with correlation values and 95% confidence intervals were reported for multiple regression analysis.

Results

Demographic Characteristics

A total of 276 adolescents participated in this study, comprising 98 boys and 178 girls. The mean age was 13.8 years, and the mean BMI was 30.3 kg/m².

Physical Activity Levels

Analysis of physical activity levels using the modified PAQ-C questionnaire revealed concerning patterns. Most participants (79.0%) reported no physical activity per week, while 19.9% reported one hour of physical activity weekly. Only 1.1% of participants reported engaging in two hours of physical activity per week.

Screen Time Assessment

Screen time analysis using the modified PAQ-C questionnaire assessed usage during weekdays and weekends, average daily duration, device types, activity nature, and late-night usage patterns. Results demonstrated that 31.9% of participants engaged in television viewing or video game playing five times per week. Additionally, 33.3% reported average daily screen time of 2–3 hours, while 10.1% limited their daily screen exposure to one hour. Laptops were the most commonly used device, reported by 29% of respondents. Furthermore, 44.9% of participants engaged in screen-related activities during late-night hours.

Association Analysis

The association analysis between physical activity levels, screen time, and cardiorespiratory parameters revealed significant findings. Physical inactivity scores demonstrated a 61.5% significant positive correlation with screen time, a 16.7% negative correlation with rate of perceived exertion, and a 12.3% positive correlation with oxygen saturation. However, screen time showed no significant associations with cardiorespiratory parameters (Table 1).

Table 1
Association of Screen Time with Physical activity levels on Cardio respiratory Fitness

<i>Parameters</i>	<i>PAQ-C</i>	<i>p-value</i>	<i>Screen time</i>	<i>p-value</i>
Screen time	0.615**	< 0.01*	-	-
Distance covered by participant	0.105	0.08	0.059	0.32
Age (years)	-0.103	0.08	0.018	0.76
Body mass index	0.055	0.36	0.109	0.07
Systolic	0.005	0.99	0.062	0.30
Diastolic	-0.079	0.91	0.046	0.44
Rate of perceived exertion	-0.167**	< 0.01*	-0.004	0.94
Heart rate	-0.115	0.06	0.046	0.44
Oxygen saturation	0.123*	< 0.04*	0.050	0.41
Standard distance	-0.037	0.99	-0.072	0.23
*p < 0.05 was considered Statistically Significant				

Exercise Testing Results

The 3-minute walk test results demonstrated significant physiological responses. Significant increases were observed in systolic blood pressure, diastolic blood pressure, exertion levels, and heart rate from pre- to post-test (all $p < 0.05$). However, no significant changes were detected in oxygen saturation levels ($p > 0.05$) (Table 2).

Table-2 Pre and Post Exercise Test Comparison

Variables	Pre		Post		p-value
	Mean	SD	Mean	SD	
Systolic	104.6	15.6	112.5	17.4	< 0.01*
Diastolic	68.9	11.4	74.2	13.6	< 0.01*
Exertion Level	6.0	0.01	7.3	1.6	< 0.01*
Heart rate	96.2	16.9	115.6	21.8	< 0.01*
Oxygen saturation	97.5	4.3	97.4	5.9	0.85
*p < 0.05 was considered Statistically Significant Using Paired Sample t-test					

Regression Analysis

Multiple regression analysis examining relationships between physical activity levels, distance covered, screen time, and cardiorespiratory parameters revealed several significant associations. BMI, systolic blood pressure, and oxygen saturation showed direct associations with PAQ-C scores. Distance covered during the test demonstrated direct associations with systolic blood pressure, rate of perceived exertion, heart rate, and oxygen saturation. Screen time showed direct relationships with BMI, diastolic blood pressure, heart rate, and oxygen saturation. Correlation values and confidence intervals were reported for all parameters (Table 3).

Table-3: Relationship of PAQ-C, Distance Covered by Participants and Screen Time on Cardio Respiratory parameters

<i>Dependent Variables</i>	<i>Parameter</i>	<i>Beta Coefficient</i>	<i>r-value</i>	<i>95% Confidence Interval</i>	
				<i>Lower Bound</i>	<i>Upper Bound</i>
PAQ-C	Age (years)	-0.028	-1.868	-0.058	0.002
	BMI	0.004	1.111	-0.003	0.01
	Systolic BP	0.001	0.755	-0.002	0.004
	Diastolic BP	-0.003	-1.447	-0.007	0.001
	Rate of perceived exertion	-0.028	-2.29	-0.053	-0.004
	Heart Rate	-0.002	-1.675	-0.004	0
	oxygen saturation	0.006	1.748	-0.001	0.013
Distance covered by participant	Age (years)	-0.589	-0.18	-7.025	5.847
	BMI	-0.812	-1.139	-2.215	0.591
	Systolic BP	0.086	0.248	-0.6	0.772
	Diastolic BP	-0.294	-0.714	-1.106	0.517
	Rate of perceived exertion	7.907	2.961	2.65	13.163
	Heart Rate	0.027	0.127	-0.392	0.446
	oxygen saturation	0.717	0.94	-0.784	2.217
Screen time	Age (years)	-0.001	-0.033	-0.063	0.061
	BMI	0.01	1.395	-0.004	0.023
	Systolic BP	0.00	0	-0.007	0.007
	Diastolic BP	0.001	0.172	-0.007	0.009
	Rate of perceived exertion	-0.003	-0.106	-0.054	0.048
	Heart Rate	0.001	0.41	-0.003	0.005
	oxygen saturation	0.003	0.432	-0.011	0.018

Discussion

This study examined the relationships between screen time, physical inactivity, and cardiorespiratory fitness parameters among healthy adolescents aged 10–16 years from urban Karachi. These factors are interconnected and represent important modifiable predictors of current and future health outcomes.

The results demonstrated significant associations between physical activity levels and screen time parameters. Participants with higher physical inactivity scores showed a 61.5% significant positive association with screen time and a 12.3% positive association with oxygen saturation. Conversely, a 16.7% negative association was observed with the rate of perceived exertion. These findings align with recent literature by Santos et al., who examined relationships between screen time, physical inactivity, and CRF. Their research indicated that even small amounts of moderate-to-vigorous physical activity daily could improve CRF in children and adolescents. Specifically, increasing moderate-vigorous physical activity through reduced screen time may help improve CRF outcomes [12]. However, some studies present contrasting findings. Denton et al. found no significant association between screen time and CRF, emphasizing that moderate and vigorous physical activity better predicted fitness outcomes in school-aged children compared to sedentary behavior [13].

The current study's 3-minute walk test results demonstrated positive associations between systolic blood pressure, diastolic blood pressure, rate of perceived exertion, heart rate, and physical activity levels ($p < 0.05$). No association was observed with oxygen saturation ($p = 0.85$). These findings correspond with research by Khamsuk et al., whose study involving a 6-minute walk test in normal-weight and overweight/obese female adolescents reported significant increases in systolic blood pressure ($p = 0.02$) and respiratory rate post-exercise, but no significant change in oxygen saturation at six minutes ($p = 0.322$) [14]. Contrasting results were published by Innocenti et al. in 2021, who reported significant decreases in oxygen saturation levels during the 6-minute walk test in teenagers with cystic fibrosis, suggesting that test responses may vary significantly across different populations [15].

The regression analysis revealed relationships between physical inactivity, distance covered during the 3-minute walk test, screen time, and cardiorespiratory parameters. BMI, systolic blood pressure, and oxygen saturation correlated directly with PAQ-C scores, while distance covered showed direct associations with systolic blood pressure, rate of perceived exertion, heart rate, and oxygen saturation. These findings are consistent with previous research by Heshmat et al., who conducted comprehensive research on adolescents and found that participants with limited physical activity and high screen time had significantly higher systolic blood pressure, diastolic blood pressure, BMI, waist circumference, and LDL levels, along with lower HDL levels. This indicates that limited physical activity combined with excessive screen time represents a significant risk factor for cardiovascular disease development [16]. However, a study published in BMC Public Health examining children aged 9–15 years found no connection between screen time habits and objectively measured moderate-to-vigorous physical activity (MVPA), despite some cross-sectional associations [17].

Furthermore, this study found that heart rate, oxygen saturation, and rate of perceived exertion were related to screen time. These findings align with an extensive study that examined cardiovascular markers, including blood pressure and heart rate variability, under minor functional stress in over 4,000 Moscow primary school students aged 7–12 years. The researchers concluded that excessive screen time altered autonomic heart rate regulation without increasing blood pressure [18]. According to a comprehensive review and meta-analysis of 13 observational studies, heart rate variability and sedentary

time showed no significant correlation. A small increase in resting heart rate was observed, but it was not considered clinically meaningful. However, the relationship between screen time and heart rate found in the current study requires further investigation, as screen-based sedentary behavior may have minimal impact on resting heart rate or autonomic function [19–20].

Clinical Implication

These findings highlight the need for improving health-related physical fitness and reducing screen time among adolescents. Recommendations include designing structured physical activity programs in schools with mandatory exercise sessions, active classroom breaks, and encouraging sports participation. Additionally, educational programs should target parents, teachers, and students regarding health risks associated with sedentary lifestyles.

Future studies should employ validated instruments, objective measures such as accelerometry and VO_2 max testing, and representative sampling methods to better understand the complex relationships between screen time, physical activity, and cardiorespiratory fitness in adolescents.

Conclusion

This study represents a novel attempt to assess cardiorespiratory fitness among adolescents in urban Karachi, Pakistan, focusing on modifiable predictors such as physical inactivity and screen time. The findings provide valuable insights for promoting healthy lifestyle interventions in this population.

Abbreviations

BMI

Body Mass Index

CVD

Cardiovascular Diseases

CRF

Cardiorespiratory Fitness

CI

Confidence Interval

DALYs

Disability Adjusted Life Years

DBP

Diastolic Blood Pressure

GBD

Global Burden of Disease

IRB

Institutional Review Board

NCD

Non-communicable diseases

PA

Physical Activity

PAQ-C

Physical Activity Questionnaire for Older Children

SBP

Systolic Blood Pressure

3MWT

3-minute walk test

Declarations

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Contributions

SH, NFP, TE, ASB and ABT: Conception and design of the study, Data collection or acquisition, Data analysis and interpretation.

FAR and SH: Drafting or critical revision of the manuscript and Approval of the final version for submission.

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Ethics approval and consent to participate

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Karachi Institute of Physiotherapy and Rehabilitation Sciences (KIPRS) (IRB-23/08/KIPRS/Approval/2024-01). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and relevant institutional and national guidelines. Written informed consent was obtained from the parents/guardians of all participants prior to their participation in the study. Assent was also obtained from the adolescent participants, where applicable.

Consent for publication

Not applicable

Competing interests

The authors claim to have no conflicts of interest.

References

1. Roccliffe P, Adamakis M, Keefte BT, Walsh L, Bannon A, Garcia Gonzalez L, et al. The impact of typical school provision of physical education, physical activity and sports on adolescent mental health and wellbeing: A systematic literature review. *Adolesc Res Rev*. 2023;12:339–64.
2. Sember V, Duric S, Starc G, et al. Secular trends in skill-related physical fitness among Slovenian children and adolescents from 1983 to 2014. *Scand J Med Sci Sports*. 2023;33(11):2323–39.
3. Roldao da Silva P, Castilho Dos Santos G, Marcio da Silva J, Ferreira de Faria W, de Gonçalves R, Stabelini Neto A. Health-related physical fitness indicators and clustered cardiometabolic risk factors in adolescents: A longitudinal study. *J Exerc Sci Fit*. 2020;18(3):162–7.
4. Prince SA, Dempsey PC, Reed JL, et al. The Effect of Sedentary Behaviour on Cardiorespiratory Fitness: A Systematic Review and Meta-Analysis. *Sports Med*. 2024;54(4):997–1013.
5. Ding D, Lawson KD, Kolbe-Alexander TL, Finkelstein EA, Katzmarzyk PT, van Mechelen W, et al. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *Lancet*. 2016;388(10051):1311–24.
6. Kalra A, Jose AP, Prabhakaran P, Kumar A, Agrawal A, Roy A, et al. The burgeoning cardiovascular disease epidemic in Indians—perspectives on contextual factors and potential solutions. *Lancet Reg Health Southeast Asia*. 2023;12:1001–56.
7. Timmis A, Vardas P, Townsend N, Torbica A, Katus H, De Smedt D, et al. European Society of Cardiology: cardiovascular disease statistics 2021. *Eur Heart J*. 2022;43(8):716–99.

8. Rath S, Tariq M, Mushoriwa F, Chigumete T, Morobi T, Srinivas S. Economics of non-communicable diseases: case study of South Africa and India. *Int J Occup Environ Health*. 2015;8(3).
9. Wu S, Xu W, Guan C, Lv M, Jiang S, Jinhua Z. Global burden of cardiovascular disease attributable to metabolic risk factors, 1990–2019: an analysis of observational data from a 2019 Global Burden of Disease study. *BMJ Open*. 2023;13(5):93–7.
10. Odiaga JA, Doucette J. Technological media and sedentary behavior in pediatrics. *J Nurse Pract*. 2017;13(1):72–8.
11. Kolimechkov S, Petrov L, Alexandrova A. Physical activity assessment using a modified PAQ-C questionnaire. In: *Proceedings of the International Scientific Congress Applied Sports Sciences*; 2017 Dec 1–2; Sofia, Bulgaria. pp. 346–350.
12. Li M, Yin X, Li Y, Sun Y, Zhang T, Zhang F, et al. Associations between Sedentary Time and Sedentary Patterns and Cardiorespiratory Fitness in Chinese Children and Adolescents. *Child (Basel)*. 2022;9(8):1140.
13. Denton SJ, Trenell MI, Plötz T, Savory LA, Bailey DP, Kerr CJ. Cardiorespiratory fitness is associated with hard and light intensity physical activity but not time spent sedentary in 10–14 year old school children: the HAPPY study. *PLoS ONE*. 2013;8(4):e61073.
14. Khamsuk K, On-Ong-Arj P, Chaisawang P, Promsrisuk T. Evaluation of Performance Capacity and Cardiorespiratory Fitness Using the 6-Minute Walk Test in Normal Weight and Overweight/Obese Female Adolescents. *J Exerc Physiol Online*. 2023;26(2).
15. Innocenti D, Masi E, Taccetti G, Genito M, Balestri E, Berghelli AR, et al. Six minute walk test in Italian children with cystic fibrosis aged 6 and 11. *Monaldi Arch Chest Dis*. 2021;92:93.
16. Heshmat R, Qorbani M, Shahr Babaki AE, Djalalinia S, Ataei-Jafari A, Motlagh ME, et al. Joint Association of Screen Time and Physical Activity with Cardiometabolic Risk Factors in a National Sample of Iranian Adolescents: The CASPIANIII Study. *PLoS ONE*. 2016;11(5):e0154502.
17. Dalene KE, Anderssen SA, Andersen LB, Steene-Johannessen J, Ekelund U, Hansen BH, et al. Cross-sectional and prospective associations between sleep, screen time, active school travel, sports/exercise participation and physical activity in children and adolescents. *BMC Public Health*. 2018;18(1):705.
18. Pankova NB, Alchinova IB, Kovaleva OI, Lebedeva MA, Khlebnikova NN, Cherepov AB, et al. Effects of Screen Time and Season on Cardiovascular System Indicators in Primary School children. *Hum Physiol*. 2021;47(6):628–38.
19. Alansare AB, Bates LC, Stoner L, Kline CE, Nagle E, Jennings JR, et al. Associations of Sedentary Time with Heart Rate and Heart Rate Variability in Adults: A Systematic Review and Meta-Analysis of Observational Studies. *Int J Environ Res Public Health*. 2021;18(16):8508.
20. Nataraj M, Sinha MK, Bhat A, Vaishali K. Correlation between physical activity, cardiorespiratory fitness, and heart rate variability among young overweight adults. *J Taibah Univ Med Sci*. 2022;17(2):304–10.