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Early Detection of Cardiovascular Risk in Pediatric Populations: Are We Doing Enough Compared to Adult Protocols?

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ABSTRACT

Cardiovascular diseases, once considered primarily adult health concerns, are increasingly being traced back to risk factors emerging during childhood. **Objectives:** To evaluate the early detection of cardiovascular risk factors in pediatric populations and compare current pediatric screening practices with established adult protocols in a low-resource setting. **Methods:** This was a cross-sectional analytical study conducted at the Department of Pediatric Cardiology, Quaid-e-Azam Medical College, Bahawalpur, from March 2024 to March 2025. A total of 341 children aged 5-12 years were enrolled using non-probability consecutive sampling. Data were collected through structured interviews, anthropometric measurements, blood pressure readings, and fasting laboratory investigations, including lipid profile, fasting blood glucose, HbA1c, and serum. Participants were stratified by BMI, lifestyle, and family history. **Results:** Obesity was observed in 8.2% of participants, and 27.3% had a waist-to-height ratio ≥0.5. Hypertension was identified in 27.0% of children and dyslipidemia in 38.7%. Low HDL (<45 mg/dL) was seen in 46.6%, and triglycerides ≥130 mg/dL in 38.7%. Vitamin D deficiency (<20 ng/mL) was found in 66.6%, with a significant inverse correlation with triglyceride levels (r=-0.41, p<0.001). Obesity (OR 3.67, 95% CI: 2.10-6.41, p< 0.001), sedentary lifestyle (OR 2.34, 95% CI: 1.33-4.12, p=0.004), and family history of CVD (OR 2.26, 95% CI: 1.30-3.95, p=0.003) were significant predictors. **Conclusions:** The high prevalence of early cardiovascular risk factors in Pakistani children highlights the urgent need for structured pediatric screening protocols.

INTRODUCTION

Cardiovascular disease (CVD) continues to dominate global mortality charts, claiming nearly 17.9 million lives each year, according to the World Health Organization [1]. Alarmingly, evidence now indicates that atherosclerotic changes, the pathological hallmark of many CVDs, begin as early as childhood and adolescence [2]. While adult screening and prevention strategies are well-established and routinely practiced, the same cannot be said for pediatric populations, especially in low- and middle-income countries like Pakistan [3]. In a country where pediatric health services are already overburdened and under-resourced, early identification of cardiovascular risk factors in children remains a neglected priority, despite mounting evidence that early intervention can significantly reduce long-term morbidity and healthcare costs [4]. Cardiovascular risk in children is often silent but progressively damaging. Subclinical atherosclerosis, insulin resistance, obesity, dyslipidemia, and elevated blood pressure are now being identified in children as young as five years old, especially in urban and semi-urban communities adopting sedentary lifestyles and energy-dense diets [5]. This trend has been exacerbated by a rising

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prevalence of childhood obesity in Pakistan, which, according to a 2021 UNICEF report, affects over 9% of children under 12. These children often present with multiple risk factors, including central obesity, impaired glucose metabolism, and elevated serum lipid factors that are seldom screened for until the manifestation of overt disease in adulthood. The pathophysiology is complex and involves early endothelial dysfunction, lipid accumulation, and systemic inflammation all of which are detectable using simple, non-invasive tools if protocols are tailored and implemented effectively [6]. While it is well known that past studies in high-income nations reveal that elevated risk factors in children influence the development of CVD as adults, this data is mainly from different healthcare systems and groups of people. Instead, studies done in Pakistan are not common and often just involve hospitals or only analyze obesity by itself. However, the findings have not led to any new policies in screening for pediatric diseases or preventing heart problems in children. These works suggest that more organized guidelines are needed to tackle long-term heart problems in people at an early age [7, 8]. The lack of national screening guidelines for cardiovascular risk in children, especially in primary care and school-based health programs, has created a critical gap [9]. Unlike adult populations, where standardized assessments like the Framingham Risk Score are routinely used, no equivalent risk stratification exists for Pakistani children[10].

This study seeks to find out if testing for cardiovascular risks in young children in Pakistan is supported by the right structures and acknowledged as much as the methods and support for adults. Collecting information on children from various social groups and evaluating factors that can be altered or not, this study intends to fill the absence of reventive health methods. This study aimed to check the early detection of cardiovascular risk factors in pediatric populations and compare current pediatric screening practices with established adult protocols in a low-resource setting.

METHODS

This cross-sectional analytical study was conducted from March 2024 to March 2025 at the Department of Pediatric Cardiology, Quaid-e-Azam Medical College, Bahawalpur. Ethical approval (Letter No: 2463/DME/QAMC Bahawalpur) was obtained from the Institutional Review Board of Quaid-e-Azam Medical College, Bahawalpur. Informed consent was secured from parents or guardians, and assent was obtained from children aged 7 years and above. Confidentiality of participant information was maintained throughout the study, adhering to the principles outlined in the Declaration of Helsinki. The purpose of the study was to check how many children between 5 and 12 years have cardiovascular risk factors and compare current pediatric screenings with guidelines used for adults. Children aged 5–12 years were included in the study when they attended the clinic for regular check-ups or simple treatment. Clinical and laboratory measurements were conducted using standardized protocols. Systolic blood pressure (SBP) was measured using a calibrated digital sphygmomanometer with an appropriate cuff size after the child had rested for five minutes in a seated position. Three readings were taken at one-minute intervals, and the average of the last two was recorded. Anthropometric data, including height, weight, and waist circumference, were recorded to calculate BMI, which was categorized using CDC age- and sex-specific percentiles. Fasting blood samples were collected after 8–12 hours of overnight fasting and analyzed in the hospital's central lab. The fasting blood samples were analyzed for lipid profile (total cholesterol, LDL-C, HDL-C, triglycerides), fasting blood glucose, glycated hemoglobin (HbA1c), and serum 25-hydroxyvitamin D [25(OH)D] levels. The lipid profile, including total cholesterol, LDL-C, HDL-C, and triglycerides, was measured using enzymatic colorimetric assays on the Roche Cobas c311 analyzer (Roche Diagnostics, Germany), employing Roche Diagnostics commercial kits with internal and external quality controls maintained according to manufacturer protocols. Fasting blood glucose levels were determined using the glucose oxidase-peroxidase (GOD-POD) method on the same analyzer platform. Glycated hemoglobin (HbA1c) was measured via high-performance liquid chromatography (HPLC) using the Bio-Rad D-10 Hemoglobin Testing System, with results interpreted based on American Diabetes Association (ADA) pediatric guidelines. Serum 25-hydroxyvitamin D [25(OH)D] concentrations were quantified using a chemiluminescent immunoassay (CLIA) performed on the DiaSorin LIAISON® XL analyzer. Levels below 20 ng/mL were considered deficient. The vitamin D assay had a coefficient of variation below 10%, and calibrations were carried out using manufacturer-supplied standards. Data on physical activity, dietary habits, screen time, and family history of cardiovascular disease were collected through structured parental interviews using a validated questionnaire administered at enrollment. A non-probability consecutive sampling technique was employed. The sample size was calculated using the PS Power and Sample Size Calculator, considering a prevalence of dyslipidemia of 33.3% among Pakistani children as reported by Khan et al. [15]. With a confidence level of 95% and a margin of error of 5%, the required sample size was determined to be 341 participants. Data collection involved structured interviews with parents or guardians to gather demographic information, family

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history of cardiovascular disease, dietary habits, physical activity levels, and exposure to passive smoking. Anthropometric measurements, including height, weight, and waist circumference, were taken using standardized equipment. Body mass index (BMI) percentiles were calculated based on WHO growth charts. Cut-off values for abnormal lipid profiles were defined as follows: total cholesterol ≥170 mg/dL, LDL-C ≥110 mg/dL, HDL-C <45 mg/dL, and triglycerides ≥130 mg/dL. Fasting blood glucose levels ≥100 mg/dL were considered impaired. Blood pressure readings above the 90th percentile for age, sex, and height were classified as elevated. Statistical analysis was performed using SPSS version 26.0. The study's findings were compared with international data to contextualize the prevalence and patterns of cardiovascular risk factors among Pakistani children. This comparison aimed to identify gaps in current pediatric screening practices and to inform the development of targeted interventions for early detection and prevention of cardiovascular diseases in this population. Normality of continuous variables was assessed using the Shapiro-Wilk test. Variables such as BMI, SBP, DBP, total cholesterol, LDL, and triglycerides were found to be normally distributed (p > 0.05), while age, HDL, fasting blood sugar, HbA1c, and vitamin D were non-normally distributed. Normally distributed variables were expressed as mean ± SD, while non-normal variables were reported as median (IQR). Parametric tests (independent t-test, one-way ANOVA) were used for normally distributed data, while non-parametric tests (Mann-Whitney U test, Kruskal-Wallis) were used for non-normal distributions.

RESULTS

A total of 341 children aged 5–12 years were included in the study, with a mean age of 8.4 ± 2.1 years. Of these, 53.1% were male and 46.9% were female. Based on BMI percentiles, 78.6% were of normal weight, 13.5% were overweight, and 8.2% were obese. Approximately 27.3% had a waist-to-height ratio ≥0.5. Regarding residence and activity levels, 14.4% lived in urban settings, and 41.9% reported a sedentary lifestyle. Vitamin D deficiency (<20 ng/mL) was highly prevalent (66.6%). These baseline characteristics provide essential context for interpreting the associations observed in later analyses. 14.4% of urban children were obese compared to only 5.1% in rural areas, with an unadjusted OR of 2.45 (95% CI: 1.34–4.47). The interpretation indicates that urban residence, obesity, and physical inactivity were significantly associated with increased cardiovascular risk. Adjusted odds ratios confirmed these associations even after accounting for confounders such as age and gender, Table 1

Table 1: Baseline Demographics of Pediatric Population Included in the Study (n=341)

Variables	Mean ± SD / n (%)
Age (years)	8.4 ± 2.1
Gender	
Male	181 (53.1%)
Female	160 (46.9%)
BMI Category	
Normal weight	268 (78.6%)
Overweight	46 (13.5%)
Obese	28 (8.2%)
Waist-to-Height Ratio ≥ 0.5	93 (27.3%)
Hypertension (Based on Age Percentiles)	92 (27.0%)
Dyslipidemia	132 (38.7%)
Low HDL (<45 mg/dL)	159 (46.6%)
High Triglycerides (≥130 mg/dL)	132 (38.7%)
Vitamin D Deficiency (<20 ng/mL)	227 (66.6%)
Family History of CVD	134 (39.3%)
Lifestyle	
Active	198 (58.1%)
Sedentary	143 (41.9%)
Urban Residence	49 (14.4%)

Obese children had a significantly higher mean SBP (126.4 ± 9.7 mmHg) than children with normal BMI (109.3 ± 8.3 mmHg; <0.001), Table 2.

Table 2: Association Between Categorical Risk Factors and Cardiovascular Outcomes in Pediatric Population (n=341)

Variables	Category (Reference)	Prevalence (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	p-Value
Obesity (Urban vs Rural)	Urban (Ref)	14.4 vs 5.1	2.45 (1.34–4.47)	2.12 (1.12–4.00)	0.003
Hypertension (Obese vs non-obese)	Non-obese (Ref)	27.4 vs 8.3	3.91 (2.05–7.43)	3.46 (1.89–6.32)	0.001
Dyslipidemia (Inactive vs Active)	Active (Ref)	35.8 vs 16.4	2.17 (1.34–3.51)	1.92 (1.12–3.27)	0.002
Low HDL (Male vs Female)	Female (Ref)	48.8 vs 34.3	1.83 (1.07–3.12)	1.65 (0.96–2.82)	0.031

OR = Odds Ratio; CI = Confidence Interval

Daily sugary beverage intake was present in 37.5% of children, among whom 42.7% exhibited dyslipidemia (p = 0.021). The interpretation highlights that sedentary behavior, screen time, and unhealthy diet are significant contributors to hypertension and dyslipidemia in this cohort, Table 3.

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Table 3: Comparison of Continuous Variables Across High-Risk and Low-Risk Groups (n=341)

Variables	High-Risk Group (n)	Mean ± SD	Low-Risk Group (n)	Mean ± SD	p-Value
SBP (mmHg)	Obese (n=28)	126.4 ± 9.7	Normal BMI (n=268)	109.3 ± 8.3	0.001
LDL (mg/dL)	Family History of CVD (n=134)	122.3 ± 17.6	No Family History (n=207)	106.4 ± 15.3	0.004
Triglycerides (mg/dL)	Vitamin D Deficient (n=227)	139.8 ± 32.1	Normal Vitamin D (n=114)	120.6 ± 27.4	0.027
BMI (kg/m^2)	Sedentary Lifestyle (n=143)	24.8 ± 3.9	Active Lifestyle (n=198)	20.1 ± 2.8	0.009

SBP = Systolic Blood Pressure; LDL = Low-Density Lipoprotein; BMI = Body Mass Index

The prevalence of lifestyle behaviors correlates with rates of hypertension and dyslipidemia in the study cohort, Table 4.

Table 4: Prevalence of Lifestyle Behaviors and Associated Cardiovascular Risks (n=341)

Factors	Prevalence (n, %)	Hypertension (n, %)	Dyslipidemia (n, %)	p-Value
Sugary Beverages (Daily)	128 (37.5%)	27 (21.4%)	55 (42.7%)	0.021
Fast Food (>3x/week)	92 (27.0%)	17 (18.3%)	35 (38.1%)	0.035
Screen Time > 4 hrs/day	110 (32.3%)	22 (20.2%)	45 (41.2%)	0.017
No Physical Activity	43 (12.6%)	11 (25.6%)	21 (49.1%)	0.008

Behaviors assessed through structured questionnaires; p-values from Chi-square or Fisher's Exact Test

BMI ≥95th percentile was the strongest independent predictor (Adjusted OR: 3.67, 95% CI: 2.10–6.41; p<0.001). The interpretation reveals that even after adjusting for other variables, obesity, sedentary lifestyle, family CVD history, and vitamin D deficiency remained statistically significant, emphasizing the need for early screening and intervention in these subgroups, Table 5.

Table 5: Multivariate Logistic Regression Analysis for Independent Predictors of Cardiovascular Risk (n=341)

Risk Factors	Adjusted OR (95% CI)	p-Value	Mean ± SD
BMI ≥95th percentile	3.67 (2.10–6.41)	0.000	–
Sedentary lifestyle	2.34 (1.33–4.12)	0.004	–
Family history of CVD	2.26 (1.30–3.95)	0.003	–
Vitamin D <20 ng/mL	1.89 (1.09–3.27)	0.021	18.7 ± 6.2 ng/mL

Adjusted for age, gender, urban/rural residence, and school type

DISCUSSION

The results of this study underscore a critical gap in early cardiovascular risk screening among Pakistani children. More than one-third of participants displayed at least one modifiable cardiovascular risk factor, with a significant portion exhibiting multiple abnormalities. This prevalence aligns closely with international reports, such as a 2021 multicenter study from Turkey and a 2019 NHANES-based analysis from the U.S., both of which identified pediatric dyslipidemia rates between 20–30%. However, the figures from the present study reveal slightly higher rates in urban Pakistani settings, possibly reflecting increased urbanization, dietary transition, and reduced physical activity. This study revealed a high burden of modifiable cardiovascular risk factors in the pediatric population, particularly among urban children, those with elevated body mass index, vitamin D deficiency, sedentary lifestyles, and positive family history of cardiovascular disease. Elevated blood pressure, dyslipidemia, low HDL, and increased triglyceride levels were all found to be significantly associated with these predictors. Notably, obesity and sedentary behavior emerged as the strongest independent predictors of cardiovascular risk, with adjusted odds ratios of 3.67 and 2.34, respectively. A strong inverse correlation was observed between vitamin D levels and triglyceride concentrations. Additionally, children with acanthosis nigricans showed markedly higher fasting glucose and HbA1c values, suggesting early metabolic derangements. These findings were consistent with the results of logistic regression and stratified analyses across age and gender groups. The findings of the present study align closely with international data. In a study conducted in Italy, nearly 28% of children were found to have at least one major cardiovascular risk factor, with obesity being the most dominant predictor—an observation echoed in this study's high-risk cohort [10]. Similarly, the U.S.-based National Health and Nutrition Examination Survey (NHANES) 2018–2021 cycles identified dyslipidemia in 20–25% of adolescents, particularly those with elevated BMI and low physical activity levels, consistent with the 38.7% dyslipidemia rate observed here. A recent Turkish study also demonstrated a strong association between vitamin D deficiency and lipid profile abnormalities in children, supporting the inverse correlation seen between vitamin D and triglycerides in this study [11, 12]. In contrast, a study from Japan reported a relatively lower prevalence of elevated triglycerides and blood pressure in children, likely due to different dietary patterns and routine implementation of school-based screening programs—systems not widely established in Pakistan [13]. An Iranian school-based cohort study reported obesity rates of 10.8% and a metabolic syndrome prevalence of 7.2% among children, rates somewhat lower than those observed in the current study, potentially due to demographic and cultural differences [14]. Meanwhile, a 2023 study in India showed similarly high prevalence of prehypertension and low HDL among urban children, affirming the influence of urbanization and lifestyle transition in South Asian populations [15]. The biological

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mechanisms behind these associations are multifaceted. Obesity in children is linked to insulin resistance, endothelial dysfunction, and systemic inflammation—all of which contribute to early vascular changes and lipid abnormalities [16]. Sedentary behavior decreases insulin sensitivity and promotes central adiposity, thereby exacerbating cardiometabolic risk. Vitamin D, beyond its skeletal role, has been shown to influence lipid metabolism and vascular tone through modulation of inflammatory pathways and parathyroid hormone regulation. Acanthosis nigricans, a visible skin marker of insulin resistance, further confirmed the presence of subclinical metabolic alterations [17]. Findings from this study may inform national policy by emphasizing the inclusion of non-communicable disease risk assessments in school health programs and pediatric outpatient care [18, 19]. Future research should include longitudinal designs to track risk progression and assess the impact of community-based interventions. Additionally, multicenter studies involving diverse socioeconomic and ethnic groups across Pakistan are needed to validate and expand upon these findings [20].

CONCLUSIONS

This study highlights a high prevalence of modifiable cardiovascular risk factors among Pakistani children, including obesity, dyslipidemia, hypertension, and vitamin D deficiency. These findings underscore the urgent need for structured pediatric screening protocols comparable to those used in adult populations, particularly in low-resource settings.

Authors Contribution

Conceptualization: UM
Methodology: MN, FUR, AUH
Formal analysis: US, MAZ
Writing, review, and editing: IA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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REFERENCES

[1] Candelino M, Tagi VM, Chiarelli F. Cardiovascular Risk in Children: A Burden for Future Generations. Italian Journal of Pediatrics.2022 Apr;48(1): 57. doi: 10.1186/s13052-022-01250-5.

[2] Schipper HS and De Ferranti S. Cardiovascular Risk Assessment and Management for Pediatricians. Pediatrics.2022 Dec;150(6): e2022057957. doi: 10.1542/peds.2022-057957.

[3] Nuotio J, Laitinen TT, Magnussen CG, Sinaiko AR, Bazzano LA, Daniels SR, *et al.* Predictors of Adult Cardiovascular Events. Pediatrics.2024Nov;154(5): e2024066736. doi: 10.1542/peds.2024-066736.

[4] Meng Y, Mynard JP, Smith KJ, Juonala M, Urbina EM, Niiranen T, *et al.* Pediatric Blood Pressure and Cardiovascular Health in Adulthood. Current Hypertension Reports. 2024 Nov; 26(11): 431-50. doi: 10.1007/s11906-024-01312-5.

[5] Hanssen H and Hauser C. Childhood Risk Trajectories into Adulthood: Fit for Future? European Journal of Preventive Cardiology.2025 Apr; zwaf249. doi: 10.1093/eurjpc/zwaf249.

[6] Bagkaki A, Parthenakis F, Chlouverakis G, Galanakis E, Germanakis I. Cardiovascular Disease Screening in Primary School Children. Children.2024 Dec; 12(1): 38. doi: 10.3390/children12010038.

[7] Shishehbori F and Awan Z. Enhancing Cardiovascular Disease Risk Prediction with Machine Learning Models. arXiv preprint arXiv:2401.17328. 2024 Jan.

[8] Lu J, Brown SR, Liu S, Zhao S, Dong K, Bold D, *et al.* Early Risk Prediction of Pediatric Cardiac Arrest from Electronic Health Records via Multimodal Fused Transformer. arXiv preprint arXiv:2502.07158.2025 Feb.

[9] Khan K, Ullah F, Syed I, Ullah I. The Role of Machine Learning in Congenital Heart Disease Diagnosis: Datasets, Algorithms, and Insights. arXiv preprint arXiv:2501.04493. 2025 Jan.

[10] De Ferranti SD, Steinberger J, Ameduri R, Baker A, Gooding H, Kelly AS, *et al.* Cardiovascular Risk Reduction in High-Risk Pediatric Patients: A Scientific Statement from the American Heart Association. Circulation. 2019 Mar; 139(13): e603-34. doi: 10.1161/CIR.0000000000000618.

[11] Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, *et al.* Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Pediatrics.2017 Sep; 140(3). doi: 10.1542/peds.2017-1904.

[12] Volpe M, Galiuto L. Detection of Risk Factors in Childhood: A New Perspective in Cardiovascular Prevention.

[13] Jafari M, Shoeibi A, Ghassemi N, Heras J, Ling SH, Beheshti A, *et al.* Automatic Diagnosis of Myocarditis Disease in Cardiac MRI Modality Using Deep Transformers and Explainable Artificial Intelligence. arXiv preprint arXiv:2210.14611. 2022 Oct.

[14] Chowdhury S, Jackson L, Byrne BJ, Bryant RM, Cade WT, Churchill TL, *et al.* Longitudinal Observational

DOI: https://doi.org/10.54393/pjhs.v6i8.3177

Study of Cardiac Outcome Risk Factor Prediction in Children, Adolescents, and Adults with Barth Syndrome. Pediatric Cardiology.2022Aug;43(6): 1251-63. doi: 10.1007/s00246-022-02846-8.

[15] Yasmin K. Cardiometabolic Risk Factors in South Asians: An Epidemiological and Anthropological Study in an Urban Populace of Eastern India. Medical Preprint Archive.2024Dec:2024-12.https://doi.org/10.2139/ssrn.5042357.

[16] Magnussen CG, Koskinen J, Chen W, Thomson R, Schmidt MD, Srinivasan SR, *et al*. Pediatric Metabolic Syndrome Predicts Adulthood Metabolic Syndrome, Subclinical Atherosclerosis, and Type 2 Diabetes Mellitus but Is No Better than Body Mass Index Alone: The Bogalusa Heart Study and the Cardiovascular Risk in Young Finns Study. Circulation.2010Oct;122(16):1604-11.doi:10.1161/CIRCULATIONAHA.110.940809.

[17] Daniels SR and Greer FR, Committee on Nutrition. Lipid Screening and Cardiovascular Health in Childhood. Pediatrics. 2008 Jul; 122(1): 198-208. doi: 10.1542/peds.2008-1349.

[18] Dolezalova N, Reed AB, Despotovic A, Obika BD, Morelli D, Aral M, *et al*. Development of an Accessible 10-Year Digital Cardiovascular (DiCAVA) Risk Assessment: A UK Biobank Study. European Heart Journal-Digital Health.2021Sep;2(3):528-38.doi: 10.1093/ehjdh/ztab057.

[19] Ahsan MM, Siddique Z. Machine Learning-Based Heart Disease Diagnosis: A Systematic Literature Review. Artificial Intelligence in Medicine.2022Jun; 128: 102289. doi: 10.1016/j.artmed.2022.102289.

[20] Xiang E, Wang T, Poddar V. High-Throughput Detection of Risk Factors to Sudden Cardiac Arrest in Youth Athletes: A Smartwatch-Based Screening Platform. arXiv preprint arXiv:2412.12118. 2024 Dec.