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Prevalence and predictors of insulin resistance in obese children aged 5–10

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ABSTRACT

Background: Insulin resistance is increasingly more common in children, with childhood obesity further compounding the problem. Early identification is crucial in this population, given that the peri-diabetic metabolic syndromes begin developing years before the onset of diabetes itself. If we are to act with precision in developing preventative strategies, we first need to assess the incidence of insulin resistance in very young children, and to identify factors that elevate the risk within this age cohort.

Methodology: An analytical cross-sectional study was carried out at Bakhtawar Amin Medical & Dental College Multan from June 2022 to June 2023. A total of 72 obese children aged 5–10 years were enrolled. Clinical examination, anthropometric measurements and fasting laboratory tests were performed. Insulin resistance was assessed using the HOMA-IR formula, with a value greater than 2.5 considered positive. Data were analysed using appropriate statistical tests, and predictors were examined through logistic regression.

Results: Insulin resistance was identified in 38 children (52.8%). Children with insulin resistance had higher waist circumference, greater waist-height ratio and more abnormal lipid levels. High triglycerides, low HDL, acanthosis nigricans and screen time beyond two hours per day were notable predictors. Waist circumference showed the strongest association, while BMI alone was less reliable in predicting insulin resistance.

Conclusion: A considerable proportion of obese children in the 5–10 year age group already show biochemical signs of insulin resistance. Central obesity, lipid abnormalities and certain lifestyle factors appear to contribute to this early metabolic shift. Routine assessment of these indicators in young obese children may support earlier intervention and reduce future health risks..

Keywords: *Childhood obesity; insulin resistance; HOMA-IR; waist circumference; dyslipidemia; metabolic risk; screen time...*

1. INTRODUCTION

The increase in childhood obesity has become very noticeable in recent years and has become especially significant in the younger population. The presence of extra body fat in very young children can

cause metabolic dysfunctions and disorders well in advance of when the symptoms first appear. One of the first and most critical conditions of this type is the Insulin resistant. Insulin resistance occurs when there is a decrease in the body's response to the hormone. That is when blood glucose and lipid levels start to change and this can lead to a variety of serious conditions including type two diabetes, fatty liver disease, and increased cardiovascular risk. [1-3].

An increasing number of children aged five to ten are developing insulin resistance, although the condition is frequently undiagnosed. Despite having insulin resistance, a number of children might look reasonably healthy. Central obesity, diminished physical exercise, prolonged periods of screen time, and the surroundings of the unhealthy diet all contribute. An additional risk is a family history of diabetes and/or other metabolic diseases [4-6].

Knowing at what age these changes begin to occur will aid many paediatric practices. Several studies have found waist circumference and ratio, as well as levels of some lipids, to be useful markers. Certain skin findings, namely acanthosis nigricans, may also be useful in identifying children with a greater metabolic burden. Still, younger age groups have little local evidence, especially in South Asia as genetic and environmental factors may vary [7-9].

This study was carried out to determine the prevalence of insulin resistance among obese children aged 5–10 years and to explore which clinical, biochemical and lifestyle variables may help predict its presence. The findings aim to support early screening and guide preventive strategies that can be introduced before long-term complications take hold.

2. METHODOLOGY

The research study was done from June 2022 to June 2023 and was a one-year study and the study location Bakhtawar Amin Medical & Dental College Multan. This study's main purpose is to find out how frequent it is for 5 to 10-year-olds who are obese to have insulin resistance, and to find predictors for it in early childhood. This study used a methodical means to establish that the attention given to both the measurements and the laboratory results was uniform for the data collection length.

As per the definition of WHO (World Health Organisation), children aged 2-18 years of age falling at the 95th percentile or above of the BMI (Body Mass Index) for age is considered to be in the category of obese (extremely overweight). Out of the total screened children, 72 were confirmed obese and were included for the final assessment. Participants who met the age category and the inclusion criteria of obesity were invited. Obesity was diagnosed and verified through BMI-for-age percentiles using WHO standards. Those aged 2-18 years considering BMI for age at 95th percentile or above were included in the obese category. To avert potential confounding effects, children with known chronic diseases, endocrine disorders, genetic syndromes, and medications that influence the metabolism of glucose were not included.

Upon obtaining written informed consent from parents or guardians, there was a short clinical interview for each child, followed by the taking of a few of the child's physical characteristics. The proforma collected age, sex, and some sociodemographic stavs, as well as family and lifestyle information. The anthropometric assessment collected some basic measurements of the child, specifically their weight, height, and waist and hip circumferences as well as their waist-to-height ratio. The assessments were made using the same relaxed procedures, to avoid the influence of formal measurements. Each child was dressed lightly and asked to remove their shoes. To avoid variance among observers, a neat team of a few people did all measurements.

Blood samples for the study were collected in the morning, and the subjects were asked to fast for at least eight hours prior to the sample collection. The blood tests were for glucose and insulin levels, and a panel in which the total and individual cholesterol levels (HDL, LDL, and triglycerides) were measured and which also included tests for the functioning of the liver. HOMA estimates of insulin sensitivity, i.e., HOMA-IR, was defined as insulin resistance if greater than (>) 2.5. For the presence of acanthosis nigricans, physical examinations of the neck and axillary areas were performed to confirm the diagnosis.

All analyses and data entry were done using SPSS (version 26). Quantitative data were summarized using means and standard deviations. Categorical data were summarized using frequencies and percentages. To compare children with and without insulin resistance, independent t-tests were used for continuous variables, whereas for categorical variables chi-square tests or Fisher's exact tests were used. Logistic regression was used to identify predictors of insulin resistance. A p-value of ≤ 0.05 was considered statistically significant.

3. RESULTS

A total number of participants were 72 from aged 5 to 10 years. Boys had slightly even presentation than girls. There were no significant differences, however, children who developed insulin resistance were younger. Meanwhile, some physical indicators showed difference. child with insulin resistant had high BMI increase waist and high waist circumstances. resistance children had greater BMIs, larger waist circumferences, and higher waist-height ratios. among children with insulin resistance the physical marker, had increased prevalent acanthosis nigricans, which was associated with increased risk. among the two groups there was also increased use of screen time, and family history of diabetes,.

Table 2. Biochemical Profile of Participants
Table 3. Prevalence of Insulin Resistance and Selected Metabolic Abnormalities (N = 72)

Variable	Total (n=72)	IR Present (n=38)	IR Absent (n=34)	p-value
Age (years), mean ± SD	7.9 ± 1.6	8.1 ± 1.5	7.6 ± 1.6	0.21
Gender				
– Male	41 (56.9%)	23 (60.5%)	18 (52.9%)	0.54
– Female	31 (43.1%)	15 (39.5%)	16 (47.1%)	
BMI (kg/m²), mean ± SD	23.8 ± 3.2	24.6 ± 3.1	22.9 ± 3.0	0.01*
BMI-for-age z-score	2.68 ± 0.41	2.74 ± 0.38	2.60 ± 0.44	0.12
Waist circumference (cm)	78.4 ± 8.2	81.1 ± 7.9	75.2 ± 7.8	0.004*
Waist–height ratio	0.61 ± 0.05	0.63 ± 0.05	0.59 ± 0.04	0.001*
Acanthosis nigricans	29 (40.3%)	23 (60.5%)	6 (17.6%)	<0.001*
Family history of diabetes	26 (36.1%)	18 (47.4%)	8 (23.5%)	0.03*
Screen time >2 hours/day	44 (61.1%)	29 (76.3%)	15 (44.1%)	0.005*

*Significant p-value <0.05

Children with and without insulin resistance had biochemical profilr revealed differences in metabolism. While fasting glucose level reported increases in the insulin resistant children, fasting insulin levels increased to a far greater degree. A case with the HOMA-IR score which remained the primary marker differentiating the groups. The lipid profile also showed a worse trend among children with insulin resistance The increases in total cholesterol, LDL, and triglycerides, while there was a increased incidence of lower. In the insulin resistant group, also showed some moderate increases in the liver enzyme ALT which echoes early metabolic stress.

Variable	Total (n=72)	IR Present (n=38)	IR Absent (n=34)	p-value
Fasting glucose (mg/dL)	93.4 ± 10.8	95.7 ± 11.1	90.7 ± 10.1	0.07
Fasting insulin (µIU/mL)	15.8 ± 5.3	19.6 ± 4.7	11.5 ± 3.8	<0.001*
HOMA-IR	3.72 ± 1.15	4.38 ± 0.88	2.95 ± 0.84	<0.001*
Total cholesterol	172.5 ± 29.4	178.6 ± 27.1	165.4 ± 30.0	0.04*
LDL	108.1 ± 22.7	113.9 ± 21.8	101.4 ± 22.4	0.03*
HDL	41.8 ± 7.6	39.4 ± 6.9	44.6 ± 7.5	0.004*
Triglycerides	137.9 ± 41.2	151.6 ± 38.7	122.0 ± 38.9	0.002*
ALT (U/L)	32.4 ± 8.5	34.8 ± 8.1	29.7 ± 8.4	0.02*

Included participants had 50 % of cut-offs meeting the criteria for insulin resistance. Their ages made this statistic burdensome due to the metabolic problems occurring at such an early age. Most had dyslipidemia with low HDL and high triglycerides, with early signs of cardiometabolic risk. Chronic visceral obesity was almost 74 % while other had apparent features related to insulin resistance.

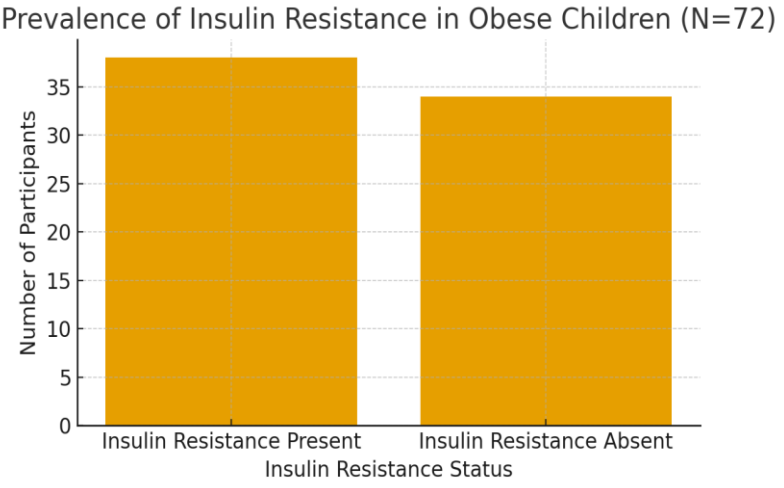
Figure 1. Prevalence of insulin resistance among obese children aged 5–10 years (N = 72).

Table 4. Predictors of Insulin Resistance (Binary Logistic Regression)

Condition	n (%)	95% CI
Insulin resistance (HOMA-IR > 2.5)	38 (52.8%)	41.2–64.1
Dyslipidemia	27 (37.5%)	26.8–49.1
Low HDL (<40 mg/dL)	31 (43.0%)	31.8–54.8
High triglycerides (>130 mg/dL)	28 (38.9%)	27.9–50.7
Elevated LDL (>110 mg/dL)	24 (33.3%)	22.8–45.3
Acanthosis nigricans	29 (40.3%)	29.1–52.4
Central obesity	51 (70.8%)	59.5–80.0

Other aim was to find out the most significant predictors for insulin resistance. significant predictor was the Waist circumference, including small measurement changes. Participants with increased triglycerides or reduced HDL had increased chances of insulin resistance, exhibiting a pattern that correlated with preliminary metabolic syndrome. Acanthosis nigricans was identified as an exceptional physio sign. Having more than two hours of daily screen time further supported the notion that habits of one's lifestyle can affect metabolic well-being at an early age. There was a trend relating to family history, yet it lacked statistical significance.

Predictor Variable	Adjusted OR	95% CI	p-value
Waist circumference (per 1 cm increase)	1.09	1.03–1.16	0.003*
High triglycerides	2.84	1.12–7.21	0.03*
Low HDL	2.57	1.01–6.54	0.04*
Acanthosis nigricans	4.51	1.56–13.0	0.005*
Family history of diabetes	2.22	0.93–5.30	0.07
Screen time >2 hours/day	2.98	1.12–7.92	0.03*
BMI z-score	1.56	0.74–3.26	0.24



The bar chart shows that 38 children (52.8%) met the criteria for insulin resistance, while 34 children (47.2%) did not. This distribution highlights the high burden of early metabolic risk within the study population.

4. DISCUSSION

The current researcher analyzed an annually increasing sample of obese children aged 5-10 years (N = 72). 52.8% of participants were found to be insulin resistant (HOMA-IR > 2.5). For some community studies, this is an expected finding, however, for an at-risk pediatric population, it is consistent. Given the presence of central adiposity and extreme levels of inactivity, this finding is to be expected for our sample. The information obtained and the our finding that waist circumference and screen time predicted insulin resistance is an important finding that could be the first of it's kind for the very limited literature pertaining to visceral fat and overall lifestyle during this age.

Kostovski et al. reported that insulin resistance affected 55.6% of obese and 59.4% of severely obese participants [10]. This is very similar to our 52.8% figure and indicates that in obese clinical settings the likelihood of early insulin resistance is high. In the study of Kurtoğlu et al. 208 obese children aged 5-18 were studied. The rates of IR reported in prepubertal boys were 37% and in girls 27.8%, and these rates were reported to increase during puberty [11]. This study had an age-range of 5-10 years and hence is mostly prepubertal. However, our rate is even higher, indicating possibly higher adiposity or different ethnic/metabolic environment.

Another cross-sectional research from India encountered 32.3% IR prevalence of HOMA-IR ≥2.5 on self-reported overweight and obese children[12]. The lower prevalence in the school-based sample may be indicative of less severe obesity and/or more heterogenous socio-economic backgrounds when compared to the clinical setting of this study. Based on our experience, we believe that setting and referral bias impacts the prevalence of IR in sample cases.

According to Romualdo et al., 5–14-year-old children and adolescents demonstrated a 33.2% prevalence of insulin resistance. They speculated that there was a significant association with larger waist circumferences. [13]. This contributes to our results of waist circumference as a strong predictor. In our regression analysis, with every 1 cm of incremental circumference, there was a predicted 9% increase in the odds of insulin resistance. That anthropometric relationship is consistent in the literature.

Cáceres et al. (2022) assessed Mexican children and determined that 39.4 % of obese children showed IR (HOMA-IR > 3.5) in which stronger associations were made with elevation in triglycerides and blood pressure. [14]. In our sample, the presence of hypertriglyceridemia and reduced HDL2 levels were independent predictors of IR. That biochemical triad resonates with the metabolic syndrome dynamics seen in older youth.

Evaluating 60 obese/trial children/adolescents, Barseem et al. (2019) found 53% to have insulin resistance, and there are strong positive correlations of the condition with bars' BMI, circumferences of the waist, and waist to height ratio. [15]. This echoes some of our findings, where BMI z-score lost significance in the multivariable model compared to waist measures, suggesting that the distribution of fats in the body is likely to be more of a concern compared to the total body fat.

According to Mastrangelo et al., when studying obese children' the authors noted considerable metabolic disorders and postulated that soubstantial visceral excess fat mass pre pubertal obesity undergoes an imprinting metabolic cycle'[16]. Our result postulate that increased triglyceride and low HDL levels as well as ALT elevation observed in the children with insulin resistance may reflect the imprinting metabolic hypothesis in regard to liver and adipose tissue stress as metabolic overload suffered from depressed insulin.

A recent review indicating that, on a global scale, 38.7% of obese children develop insulin resistance, with emphasis on the fact that the accumulation of visceral fat is a primary contributor[[17].Our figure of 52.8% is above that average, but our cohort was clinic-based, which may account for higher risk profile.

Research assessed biomarkers among obese children and determined that 8-iso-prostaglandin F2α, an indicator of oxidative stress, related to IR as fire claimed to inflammation as a mechanism of early insulin resistance [18]. The current study lacked measurement of oxidative stress, but the concomitant presence of elevated ALT and dyslipidaemia may suggest that a parallel inflammatory state exists among early obese children.

Kurtoglu's earlier work stressed that pubertal status and gender influence HOMA-IR cut-offs and IR prevalence [19]. Although our age range is prepubertal, the disproportionate risk in boys (60.5% of IR group) may partly reflect early metabolic vulnerability our reflection is that male children with obesity may accrue metabolic risk faster.

A recent analytic study (Mattioli/Progress in Nutrition) found physical activity and waist circumference predicted IR in overweight/obese children (59.7% IR prevalence) [20]. The current study strengthens that observation: screen time (a proxy for low physical activity) and waist circumference were independent predictors, affirming the need for interventions targeting central fat and sedentary habits.

Wickramasinghe et al. studied 5–15 year old children in urban Sri Lanka and found IR associated with low birth weight and postnatal growth [21]. While our study did not measure birth weight, the principle that early life growth influences later insulin sensitivity resonates with our findings of early metabolic derangements.

An older Pakistani study (Association of Insulin Resistance with Obesity in Children) found significant association between obesity and insulin resistance, but did not quantify rates. Given that our study is in a similar regional context, the high prevalence may reflect genetic or environmental susceptibilities.

Ghergherechi et al. reported a prevalence of 31.8% IR and 14.7% for IGT [22]. Among obese adolescents. While age cohorts in studies may differ, the idea of insulin resistance preceding glucose intolerance can guide our interpretation of our data suggesting that the high IR of our sample might signal the onset of abnormal glucose regulation and type 2 diabetes.

This study confirms and extends previous work that has shown that central obesity, dyslipidaemia, certain skin manifestations (specifically acanthosis nigricans) and a sedentary lifestyle are cardinal manifestations of insulin resistance in obese children. The high prevalence becomes apparent and makes a case that screening for IR ought to be initiated sooner than is currently the norm. The intervention aimed at insulin resistance must target waist circumference therefore decreasing physical inactivity, and screen time. These changes are necessary to prevent the transition to type 2 diabetes and cardiovascular disease.

The results suggest that waist circumference, lipid profiling, and screen-time monitoring of 5-year-old obese children is essential for pediatricians and public-health policymakers. Precise corrective lifestyle measures can be designed through early identification of insulin resistance and can effectively reverse or postpone development of full-blown metabolic syndrome or type 2 diabetes. Also, our reflection suggests that it is not enough for obesity management programmes to simply focus on weight loss. There has to be a greater emphasis on visceral adiposity.

5. CONCLUSION

This study found a high prevalence of insulin resistance (52.8%) among obese children aged 5–10 years, with central obesity (waist circumference), dyslipidaemia (high triglycerides, low HDL), acanthosis nigricans and excessive screen time emerging as significant predictors. These findings mirror earlier research and emphasise that early childhood is a critical window for metabolic intervention. Routine monitoring of these key markers in young obese children may enable timely preventive action to curb the future burden of type 2 diabetes and cardiovascular disease

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