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Research Article

Biochemical Predictors of Childhood Obesity and Their Public Health Implications in Low-Income Populations

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ABSTRACT

Background: Obesity in children has become a rather popular issue among low-income groups where nutritional shifts and lifestyle changes have begun to have a growing impact on health outcomes. Biochemical changes related to obesity tend to start at a young age but have not been sufficiently explored in resource-constrained studies.

Objective: To identify biochemical predictors of childhood obesity and examine their public health relevance among children from low-income backgrounds.

Methods: This cross-sectional study was conducted at Kulsum International Hospital from January 2025 to January 2026. Seventy two children aged between 5 and 12 years'. Anthropometric data were taken and the status of obesity was ascertained after taking the BMI percentile. The blood samples after fasting were tested in the levels of glucose, insulin, lipid profile, leptin, C-reactive protein, and vitamin D. The resistance to insulin was determined by HOMA-IR. The data were analyzed with the help of IBM SPSS statistics version 26. Associations were evaluated by comparative analysis, correlation analysis, and regression analysis with $p<0.05$ being considered significant.

Results: Among the participants, 25.0% were classified as obese and 27.8% as overweight. Obese children exhibited significantly higher insulin levels, HOMA-IR, triglycerides, leptin, and CRP, along with lower HDL levels ($p<0.05$). BMI showed positive correlations with insulin ($r=0.52$), leptin ($r=0.61$), and CRP ($r=0.46$), while an inverse relationship was observed with HDL ($r=-0.39$). Logistic regression identified insulin resistance, leptin, and CRP as independent predictors of obesity.

Conclusion: Biochemical disturbances, particularly insulin resistance, dyslipidemia, and low-grade inflammation, are closely linked with childhood obesity in low-income settings. To avoid long-term metabolic problems, early detection and specific public health interventions are needed.

Keywords: Childhood obesity, biochemical markers, insulin resistance, leptin, low-income population, public health

INTRODUCTION

Childhood obesity has already become a widely recognized major health concern all around the world, and the prevalence of childhood obesity is continuously increasing, not only in high-income regions, but also in low- and middle-income settings. The most common problem that has long been the leading issue in such populations is under nutrition but recent changes in dietary habits, urbanization and reduced physical activity has resulted in a parallel increase of the prevalence of overweight and obesity in children. This dual burden poses special problems to the healthcare system that is already scarce in its resources (1-3).

Childhood obesity is not just a pathology of the excess of body weight but is related to a series of metabolic disorders. Biochemical changes, including insulin resistance, dyslipidemia and hormonal imbalance usually occur at an early age and may go unnoticed without specific screening. Such changes may put individuals at

risk of developing chronic conditions such as type 2 diabetes, cardiovascular disease, and metabolic syndrome later in life. Early detection of such predictors is thus important in the timely intervention (4-6).

Among low-income populations, the causal factors of childhood obesity are multifactorial and go beyond the biological processes. The lack of access to balanced nutrition, the increased consumption of low-cost and energy-dense foods, the lack of awareness on the healthy lifestyle practices, and the limited opportunity to engage in physical activity are all contributing factors to the rising trend. Furthermore, socioeconomic factors including the level of education of parents, and the state of the household contribute to complicating the problem even further (7-9).

Although the burden is increasing, there is the relative scarcity of localized data that focuses on biochemical predictors of childhood obesity in resource constrained environment. Such associations are imperative to clinical management, as well as to planning effective strategies in promoting community health. Therefore, the present study aims to evaluate key biochemical markers associated with obesity among children in a low-income setting and to highlight their implications for early prevention and health policy planning.

METHODOLOGY

This 'analytical cross-sectional study' was conducted at Kulsum International Hospital over a period of one year, from January 2025 to January 2026. The primary objective was to evaluate biochemical indicators associated with childhood obesity and to explore their relevance within economically disadvantaged populations.

'A total of 72 children aged between 5 and 12 years were enrolled in the study'. 'A non-probability consecutive sampling technique' was used to select the participants based on outpatient and community screening settings serving mainly low-income families. Children with known chronic diseases, endocrine disorders, genetic syndromes that affect growth or receiving long term medications that may affect metabolic parameters were excluded.

The data collection process could not occur without the hospital ethical review board giving ethical approval to the process. Informed consent was obtained, both in writing, as parents or guardians and in writing where appropriate as assent of the children was obtained. All the data of the respondents was maintained in secrecy during the study process in accordance to the ethical research procedures.

A 'structured questionnaire was used to capture the demographic data such as age, gender, education level of the parent and the characteristics of the household'. Anthropometric data were obtained using 'standardized methods: body weight was measured using minimal clothing; a calibrated digital scale was used in the measurement of body weight; height was measured using a stadiometer and body mass index (BMI) was calculated as body weight in kilograms/height in meters squared (kg/m 2)'. Children were categorized as normal, overweight and obese using the age and sex-specific percentile of BMI.

The venous blood samples were done following a 8-10 hours overnight fast. Biochemical was done; fasting blood glucose, serum insulin, lipid profile (total cholesterol, LDL, HDL, and triglycerides) and inflammatory markers C-reactive protein. Measurement of hormonal markers like leptin was also done. The Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was used to estimate insulin resistance. Also, the level of micronutrients such as vitamin D was measured to investigate the nutritional effects.

SPSS was used to measure the mean and standard deviation were used to summarize quantitative variables, and frequencies and percentages were used to summarize categorical variables. The Shapiro-Wilk test was used to test the normality of continuous variables. 'The independent samples t-tests or the one way ANOVA were used to test the differences between groups in case of continuous variables and the chi-square test used to test the differences between groups in case of categorical variables'. The analysis of correlation was used to test the relationship among BMI and biochemical parameters. Logistic regression analysis was used to determine the independent predictors of obesity. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The children involved in the analysis were 72 in number and were children of low-income households. The results highlight demographic distribution, anthropometric status, biochemical markers, and their relationship with obesity. The population of the study was mostly made up of school-going children, with a marginally higher number of females. The targeted low-income environment was represented by the majority of the participants having families with a low educational level and having many people in the family.

Table 1: Demographic Characteristics of Participants

Variable	Category	Frequency (n)	Percentage (%)
Age Group	5–8 years	28	38.9
	9–12 years	44	61.1
Gender	Male	31	43.1
	Female	41	56.9
Mother's Education	Illiterate	29	40.3
	Primary	21	29.2
	Secondary & above	22	30.5
Household Size	≤5 members	26	36.1
	>5 members	46	63.9

Body composition analysis showed that significant percentage of children were overweight and obese, which is an indication that a significant burden of childhood obesity is emerging even in resource limited populations.

Table 2: Anthropometric Profile and Obesity Status

Variable	Mean ± SD / Category	Value
Weight (kg)	Mean ± SD	34.6 ± 8.2
Height (cm)	Mean ± SD	133.5 ± 9.4
BMI (kg/m²)	Mean ± SD	19.3 ± 3.1
Obesity Status	Normal	34 (47.2%)
	Overweight	20 (27.8%)
	Obese	18 (25.0%)

Biochemical analysis revealed that there was a significant change in metabolic and inflammatory indices with trends showing that overweight and obese children had early metabolic disturbances.

Table 3: Biochemical Parameters

Parameter	Mean ± SD
Fasting Glucose (mg/dL)	94.8 ± 10.5
Serum Insulin (µIU/mL)	14.6 ± 5.8
HOMA-IR	3.4 ± 1.2
Total Cholesterol (mg/dL)	168.2 ± 24.7
LDL (mg/dL)	102.6 ± 18.3
HDL (mg/dL)	41.5 ± 6.2
Triglycerides (mg/dL)	142.3 ± 30.4
Leptin (ng/mL)	18.9 ± 7.5
CRP (mg/L)	3.8 ± 1.6
Vitamin D (ng/mL)	21.4 ± 6.9

Obese children were found to have a higher level of insulin, triglycerides, leptin and inflammatory markers than the normal-weight children. Such differences were statistically significant.

Table 4: Association of Biochemical Markers with Obesity

Variable	Normal (n=34)	Obese (n=18)	p-value
Insulin (µIU/mL)	11.2 ± 3.6	19.8 ± 5.1	<0.001
HOMA-IR	2.6 ± 0.8	4.8 ± 1.1	<0.001
Triglycerides	121.5 ± 20.2	168.7 ± 28.6	<0.001
Leptin	13.4 ± 4.2	27.6 ± 6.8	<0.001
CRP	2.5 ± 0.9	5.2 ± 1.3	<0.001
HDL	44.2 ± 5.3	37.8 ± 4.9	0.002

Body mass index was statistically related to various biochemical markers, especially insulin resistance and inflammatory markers.

Table 5: Correlation of BMI with Biochemical Markers

Variable	Correlation with BMI (r)	p-value
Insulin	+0.52	<0.001
HOMA-IR	+0.55	<0.001
Triglycerides	+0.48	<0.001
Leptin	+0.61	<0.001
CRP	+0.46	<0.001
HDL	-0.39	0.002

Regression modeling has found the key biochemical markers to be key independent predictors of obesity even with the socioeconomic background in consideration.

Table 6: Logistic Regression Analysis (Predictors of Obesity)

Variable	Adjusted OR	95% CI	p-value
Insulin	1.28	1.12–1.46	0.001
HOMA-IR	1.74	1.29–2.35	<0.001
Leptin	1.36	1.15–1.61	<0.001
CRP	1.41	1.18–1.69	<0.001
Low Maternal Education	1.89	1.02–3.51	0.041

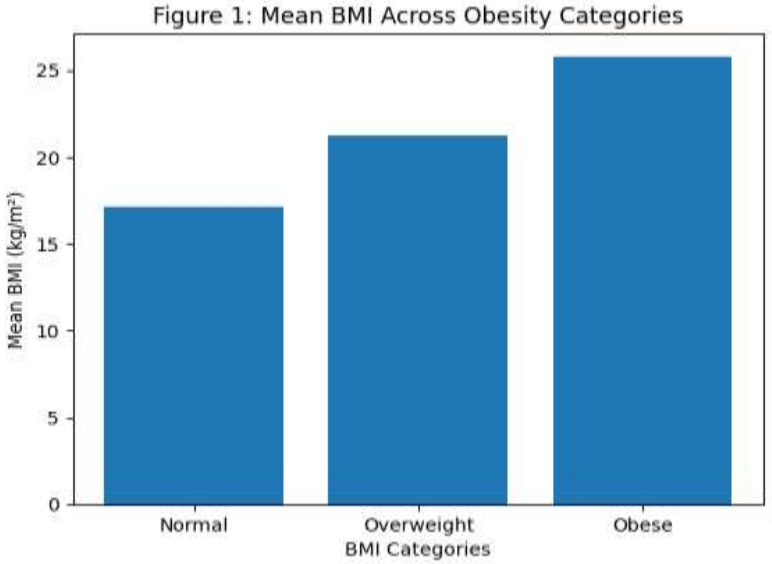

Figure 1: Mean body mass index (BMI) across weight categories demonstrates a clear upward trend from normal to obese groups, indicating increasing adiposity among children in low-income populations.

DISCUSSION

The present study explored biochemical factors linked with childhood obesity in a low-income population and demonstrated a clear association between metabolic disturbances and increased body mass index. A significant percentage of children in this generation were overweight or obese, which demonstrates that the issue of overweight and obesity is no longer exclusive to high-income households but is now increasingly witnessed in communities with constrained economic resources. This trend can be attributed to the change in food habits, lack of physical exercise and health education (10-12).

Among the key findings was the close correlation between the insulin levels, HOMA-IR, and obesity status. Children who had higher BMI exhibited higher insulin level, and insulin resistance. This implies that metabolic dysregulation can commence early in life and may be pre-clinical illness. The results confirm the idea that childhood obesity is closely associated with the initial changes in glucose metabolism that, in case of their lack of management, might lead to the development of type 2 diabetes in the later years (13-15).

The abnormalities in lipids were also more evident in the case of obese children. The elevation of triglyceride and the decrease of HDL values are indicators of the poor lipid profile that may lead to long-term cardiovascular risks. These changes, which are evident when a person

is very young, justify the need to screen young people early. Such changes can be further compounded by, in low-income populations, diets that are nutritionally imbalanced and high in low-cost energy-dense foods (16, 17).

Leptin was also found in the study as a prominent biochemical indicator that is linked to obesity. The elevated levels of leptin in obese children are likely to be a result of the increase in the mass of adipose tissue and the potential resistance to leptin. This hormonal imbalance can affect the regulation of appetite and continues to increase weight. On the same note, the high levels of C-reactive proteins in the obese participants give evidence to a low-grade inflammatory condition, which supports the realization that obesity is not only a nutritional disease but also an inflammatory disease (18).

A major factor of this study is the role played by socioeconomic factors. Young people who lived in families with less maternal education were more likely to be obese. This could be associated with the lack of awareness about healthy eating habits, limited access to healthy nutrition, and limited access to physical activities. These results highlight the fact that biological risk factors and social determinants are intertwined to a large extent (19).

In the context of a public health, the findings have important implications. 'The occurrence of biochemical abnormalities and obesity among low-income children implies a dual burden of malnutrition, in which under- and overnutrition co-exist' This trend can also result in an increase in the number of non-communicable diseases in the future, which will put even greater pressure on already scarce healthcare facilities (20).

Although the study offers valuable information, some limitations are to be taken into account. The small size of the sample and the single-center design can potentially restrict the generalization of the results. Also no detailed quantification of dietary intake and physical activity was done which could have given additional context to the observed biochemical changes. Nevertheless, in spite of these shortcomings, the research also notes some crucial associations, which should be studied in large-scale, again.

CONCLUSION

Childhood obesity in low-income populations is strongly associated with early biochemical disturbances, including insulin resistance, dyslipidemia, hormonal imbalance, and systemic inflammation. These findings indicate that metabolic risk begins at an early stage and may progress if not identified and managed promptly. The study underscores the need for integrated strategies that combine early biochemical screening, nutritional education, and community-based interventions. Addressing both biological and socioeconomic contributors is essential to reduce the growing burden of childhood obesity and its long-term health consequences.

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