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Research Article

Frequency and Predictors of Non-Alcoholic Fatty Liver Disease in Obese Adolescents Visiting a Tertiary Care center

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Abstract

Introduction: The condition Non-alcoholic fatty liver disease (NAFLD) affects obese adolescents with considerable frequency along with metabolic syndrome. The ongoing increase in obesity demands research to reveal how often NAFLD develops within this population along with its risk factors so proper intervention can occur.

Materials and Methods: The research took place at Khyber Teaching Hospital (KTH) in Peshawar during a twelve-month span from January 2023 through December 2023. Two hundred participants aged between 10 and 18 years who showed obesity signs took part in the study. The demographic data was collected, together with anthropometric measurements and clinical markers, which included BMI combined with waist circumference measurements and blood pressure screening and biochemical testing of ALT alongside fasting insulin and lipid profiles. The clinical diagnosis of NAFLD depended on ultrasound examination results. Statistical tests through the combination of chi-square tests, t-tests, and binary logistic regression were conducted in SPSS version 26.0 to determine significant predictor variables.

Results: Research findings indicated that NAFLD affected 61 out of 132 (46.2%) adolescents participating in the study. Research data demonstrated that NAFLD is linked strongly to elevated BMI measurements, bigger waist circumference, and increased blood pressure levels. Patients in the NAFLD group showed elevated levels of ALT, triglycerides, and fasting insulin in their blood tests. Among the variables evaluated by logistic regression, BMI, alongside ALT and triglyceride levels, insulin measurement, and sedentary behaviors, proved to be independent predictors of NAFLD development.

Conclusion: NAFLD shows a high incidence among obese adolescents because metabolic issues together with lifestyle patterns contribute to its formation. The population with NAFLD must undergo early screening and receive intervention with lifestyle modifications to prevent persistent liver complications. Combining public health programs that fight obesity with activity programs would help decrease the extent of NAFLD in young people.

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Introduction

One of the most common chronic liver diseases in the world, nonalcoholic fatty liver disease (NAFLD) is defined by the buildup of hepatic fat in people who drink little or no alcohol [1]. NAFLD, which was once thought to be an adult illness, is becoming better acknowledged in the juvenile population, especially in teenagers [2]. With the potential to develop to non-alcoholic steatohepatitis (NASH), fibrosis, cirrhosis, and potentially hepatocellular cancer in later life, NAFLD is a serious public health concern due to its increased frequency, which is intimately linked to the worldwide obesity pandemic [3]. To avoid long-term hepatic and metabolic problems, early identification and treatment are essential [4]. One of the main risk factors for the development of NAFLD in adolescents is obesity, particularly central or visceral obesity [5]. Additionally, additional variables including dyslipidemia, hypertension, sedentary lifestyles, bad eating habits, genetic predispositions, and components of the metabolic syndrome are frequently implicated [6]. It adds to insulin resistance, a major mechanism in the development of hepatic steatosis [7]. The adolescent period is particularly vulnerable due to rapid physical changes and hormonal fluctuations that may exacerbate metabolic imbalances, further increasing the risk of hepatic fat accumulation [8].

In developing countries like Pakistan, the prevalence of childhood and adolescent obesity is steadily increasing due to urbanization, reduced physical activity, and dietary transitions towards calorie-dense, nutrient-poor foods [9]. National estimates show that 5–20% of Pakistani adolescents are classified as overweight or obese [10]. Despite the rising numbers, NAFLD in adolescents remains underdiagnosed and under-researched, especially in clinical settings where obesity-related liver complications may not be a primary focus [11]. Most adolescents with NAFLD are asymptomatic, and the condition is often incidentally discovered through elevated liver enzymes or imaging studies, underscoring the need for targeted screening in high-risk groups [12].

Currently, there is limited regional data exploring the frequency and predictors of NAFLD among obese adolescents in Pakistan, particularly those attending tertiary care hospitals where diagnostic tools and specialist consultations are more readily available. Understanding the burden and identifying clinical and biochemical predictors in this population is essential for timely intervention and prevention of disease progression. This study aims to fill this research gap by determining the frequency and predictors of non-alcoholic fatty liver disease in obese adolescents visiting a tertiary care center.

Materials and Methods

Study Design and Setting: This cross-sectional analytical study was conducted at the Department of Pediatrics within Khyber Teaching Hospital (KTH) located in Peshawar. This 12-month research period extended from January 2023 to December 2023 to determine the frequency and essential predictors of non-alcoholic fatty liver disease in obese adolescents accessing the tertiary care facility. This research took place in a tertiary care facility that handles patients from various urban and rural locations throughout Pakistan because of its diverse patient profile.

Study Population: A total of 200 obese adolescents aged 10–18 years were initially approached using non-probability consecutive sampling, chosen for feasibility and continuous patient availability. After applying the exclusion criteria and accounting for non-consent and incomplete data, 132 participants were included in the final analysis.

Inclusion and Exclusion Criteria: The study enrolled adolescents from 10 to 18 years old who had a Body Mass Index (BMI) above or equal to the 95th percentile of their age group and sex and who gave consent to join. The study participants excluded those with documented liver diseases together with alcohol consumers or patients taking hepatotoxic drugs. Diabetes mellitus was excluded to avoid confounding effects on insulin levels and to maintain homogeneity in analyzing insulin resistance.

Sample Size Calculation: "The sample size was calculated using OpenEpi software". Using a previously reported prevalence of NAFLD in obese adolescents at 45%, a 95% confidence interval, and a margin of error of 8.5%, the minimum required sample size was estimated to be 132 participants.

Sampling Technique: Participants were recruited through non-probability consecutive sampling from

the outpatient clinic. Consecutive sampling was chosen due to practical feasibility, continuous patient flow, and resource constraints in the tertiary care setting

Data Collection Procedure: A structured data collection proforma was used to record demographic details (age, gender), clinical history, and anthropometric measurements including height, weight, BMI, and waist circumference. Blood pressure was measured using standard procedures. Physical activity and dietary habits were assessed through a brief lifestyle questionnaire. Sedentary lifestyle was defined as engaging in screen-based activities >2 hours/day and <3 days of moderate physical activity/week. All clinical and laboratory assessments were performed at a single time point during the outpatient visit.

Laboratory Investigations: All participants had venous blood samples taken after an overnight fast in order to measure a number of biochemical markers. In order to assess hepatic functioning, the examinations included "liver function tests, particularly aspartate aminotransferase (AST) and alanine aminotransferase (ALT)". Glycemic control was also evaluated by measuring fasting blood glucose levels. "Triglycerides, total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL)" were all measured as part of a comprehensive lipid profile. Insulin resistance was assessed by measuring fasting insulin levels as well. HOMA-IR was not calculated due to logistical limitations and lack of paired glucose-insulin sampling at the same time point. ALT >40 U/L, based on the reference range of the hospital's clinical biochemistry lab, was considered elevated.

Radiological Assessment: A qualified radiologist used a high-resolution ultrasound equipment to perform abdominal ultrasonography. When no other discernible liver illnesses were present, the diagnosis of nonalcoholic steatohepatitis (NAFLD) was made based on the hallmarks of hepatic steatosis, such as elevated liver parenchymal echogenicity.

Operational Definitions: According to established growth charts, obesity was defined in this study as having a body mass index (BMI) of 95th percentile or higher for both age and sex. The presence of hepatic steatosis seen by abdominal ultrasonography without the presence of secondary causes of liver fat buildup, such as alcohol use, viral hepatitis, or hepatotoxic drugs, was referred to as non-alcoholic fatty liver disease.

Data Analysis: SPSS version 26.0 was used to analyze the data. Frequencies and percentages were used to display categorical characteristics like gender and the prevalence of NAFLD. Means ± standard deviations were used to express continuous data including age, BMI, and laboratory results. "Categorical variables were compared using the chi-square test, and the means of the NAFLD and non-NAFLD groups were compared using independent t-tests. In order to determine independent predictors of NAFLD", binary logistic regression analysis was performed. Model adequacy was evaluated using the Hosmer-Lemeshow test. Discriminatory power was assessed with ROC-AUC analysis. P-values below 0.05 were regarded as statistically significant.

Ethical Considerations: The institute's Institutional Review Board granted ethical approval prior to start-up. In addition to the teenagers' verbal agreement, the parents or guardians of each participant provided written informed consent.

Results

In all, 132 obese teenagers between the ages of 10 and 18 were included in the study. The participants' average age was 14.2 ± 2.1 years. There were 64 (48.5%) ladies and 68 (51.5%) males among them. 61 patients (46.2%) had non-alcoholic fatty liver disease (NAFLD), which was identified by ultrasonographic evidence of hepatic steatosis. The study group's average waist circumference was 91.5 ± 8.9 cm, and their average body mass index (BMI) was 29.8 ± 3.7 kg/m². The average blood pressure readings were 76.3 ± 8.5 mmHg for the diastolic and 118.6 ± 11.2 mmHg for the systolic. Table 1 provides a summary of these results.

Table 1: Demographic and Anthropometric Characteristics of Study Participants

Variable	Mean ± SD / n (%)
Age (years)	14.2 ± 2.1

Gender (Male)	68 (51.5%)
Gender (Female)	64 (48.5%)
BMI (kg/m²)	29.8 ± 3.7
Waist circumference (cm)	91.5 ± 8.9
Systolic BP (mmHg)	118.6 ± 11.2
Diastolic BP (mmHg)	76.3 ± 8.5

Participants diagnosed with NAFLD demonstrated significantly higher clinical parameters compared to those without the condition. Specifically, the mean BMI among adolescents with NAFLD was 31.2 ± 3.4 kg/m², whereas it was notably lower at 28.7 ± 3.3 kg/m² in those without NAFLD ($p < 0.001$). In the NAFLD group (94.1 ± 7.9 cm) the mean waist circumference was likewise noticeably higher than in the non-NAFLD group (89.3 ± 9.1 cm; $p = 0.002$). Blood pressure measurements similarly trended in the NAFLD group exhibiting higher systolic (122.4 ± 10.6 mmHg vs. 115.3 ± 10.9 mmHg; $p = 0.001$) and diastolic (79.1 ± 7.8 mmHg vs. 73.9 ± 8.3 mmHg; $p = 0.001$). These statistically significant differences are detailed in Table 2.

Table 2: Comparison of Clinical Parameters between NAFLD and Non-NAFLD Groups

Parameter	NAFLD (n=61)	Non-NAFLD (n=71)	*p*-value
BMI (kg/m²)	31.2 ± 3.4	28.7 ± 3.3	<0.001
Waist Circumference (cm)	94.1 ± 7.9	89.3 ± 9.1	0.002
Systolic BP (mmHg)	122.4 ± 10.6	115.3 ± 10.9	<0.001
Diastolic BP (mmHg)	79.1 ± 7.8	73.9 ± 8.3	0.001

Biochemical markers exhibited significant differences between adolescents with and without NAFLD. Those diagnosed with NAFLD had notably higher levels of alanine aminotransferase (ALT), fasting insulin, and triglycerides. Specifically, the mean ALT level in the NAFLD group was 45.3 ± 18.7 U/L, significantly elevated compared to 27.8 ± 12.2 U/L in the non-NAFLD group ($p < 0.001$). Similarly, fasting insulin levels were higher in adolescents with NAFLD (22.6 ± 7.8 μU/mL) than in those without the condition (17.3 ± 6.4 μU/mL; $p < 0.001$). Triglyceride levels also showed a marked increase in the NAFLD group (163.6 ± 41.2 mg/dL) compared to the non-NAFLD group (134.5 ± 37.9 mg/dL; $p < 0.001$). Additionally, HDL levels were significantly lower in adolescents with NAFLD (38.1 ± 8.2 mg/dL) than in those without (44.5 ± 9.4 mg/dL; $p = 0.001$), further underscoring the adverse metabolic profile associated with NAFLD. Although fasting blood glucose was slightly higher in the NAFLD group (95.4 ± 12.1 mg/dL) compared to the non-NAFLD group (91.7 ± 11.3 mg/dL), the difference was not statistically significant ($p = 0.09$), as shown in Table 3.

Table 3: Comparison of Biochemical Parameters between NAFLD and Non-NAFLD Groups

Parameter	NAFLD (n=61)	Non-NAFLD (n=71)	*p*-value
ALT (U/L)	45.3 ± 18.7	27.8 ± 12.2	<0.001
Fasting Blood Glucose (mg/dL)	95.4 ± 12.1	91.7 ± 11.3	0.09
Triglycerides (mg/dL)	163.6 ± 41.2	134.5 ± 37.9	<0.001
HDL (mg/dL)	38.1 ± 8.2	44.5 ± 9.4	0.001
Fasting Insulin (μU/mL)	22.6 ± 7.8	17.3 ± 6.4	<0.001

Physical activity levels and dietary habits differed significantly between adolescents with and without NAFLD. A sedentary lifestyle was notably more prevalent among adolescents with NAFLD, reported in 74.2% (n=45) of cases compared to only 40.8% (n=29) in the non-NAFLD group ($p < 0.001$). Dietary patterns also revealed unhealthy tendencies in the NAFLD group, with frequent fast food intake reported by 63.9% (n=39) of participants versus 39.4% (n=28) in the non-NAFLD group ($p = 0.006$). Additionally, a high consumption of sugary beverages was observed in 70.5% (n=43) of adolescents with NAFLD, significantly higher than the 42.3% (n=30) in those without NAFLD ($p = 0.002$). These findings highlight the strong association between poor lifestyle habits and the presence of NAFLD in adolescents (Figure 1).

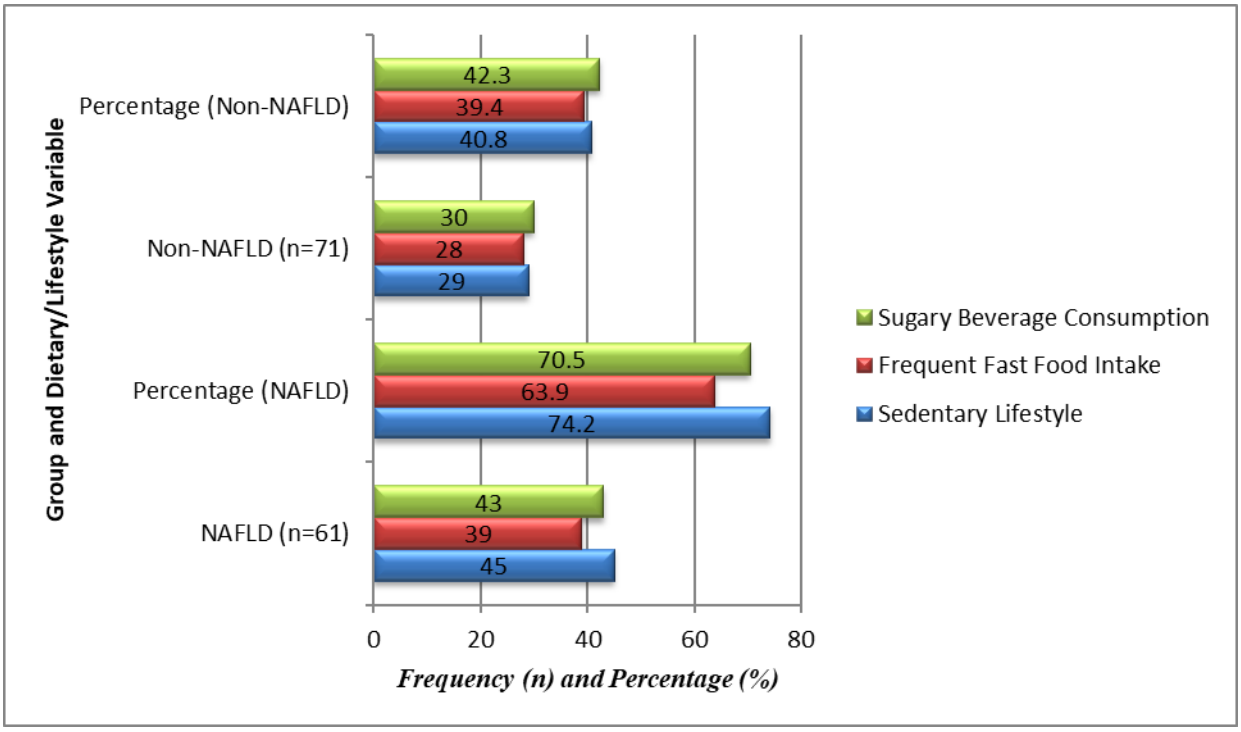

Figure 1: Lifestyle Factors Associated with NAFLD

NAFLD independent predictors were found using binary logistic regression analysis. The model contained variables with a univariate analysis $p < 0.1$. The results indicated that a number of factors functioning as independent variables may be able to strongly predict NAFLD. An elevated body mass index (BMI) was associated with a greater risk of non-alcoholic fatty liver disease (NAFLD), with an adjusted odds ratio (OR) of 1.26 per unit increase (95% CI: 1.11–1.43, $p < 0.001$). With an OR of 2.81 (95%) CI: 1.34–5.91, $p = 0.006$, elevated alanine aminotransferase (ALT) levels (>40 U/L) also emerged as a major predictor. Similarly important predictors were fasting insulin levels more than 20 µU/mL (OR: 3.02, 95% CI: 1.48–6.13, $p = 0.016$) and triglyceride levels more than 150 mg/dL (OR: 2.47, 95% CI: 1.19–5.13, $p = 0.016$). With an OR of 2.92 (95% CI: 1.38–6.18, $p = 0.005$), a sedentary lifestyle also dramatically raised the risk of NAFLD. These results highlight the multifaceted character of NAFLD, in which development of the condition depends critically on both metabolic and lifestyle aspects (Table 4).

.**Table 4:** Binary Logistic Regression Analysis for Predictors of NAFLD

Variable	Adjusted	95%	*p*-
	OR	CI	value
BMI (per unit increase)	1.26	1.11–1.43	<0.001
ALT (>40 U/L)	2.81	1.34–5.91	0.006
Triglycerides (>150)	2.47	1.19–5.13	0.016
Fasting Insulin (>20)	3.02	1.48–6.14	0.002
Sedentary Lifestyle	2.92	1.38–6.18	0.005

With regard to categorical distribution, 42 participants—31.8% of the whole study—had high liver enzymes (ALT > 40 U/L). Defined as triglycerides >150 mg/dL, hypertriglyceridemia was noted in 49 teenagers, or 37.1% of the sample. There were 58 individuals with low HDL cholesterol (<40 mg/dL), which accounted for 43.9% Forty-one teenagers, or 31.1% of the total participants, had hyperinsulinemia—that is, fasting insulin levels >20 µU/mL. Among lifestyle choices, 67 participants—or 50.8%—said they often ate fast food, while 73 participants—55.3%—regularly drank sugary beverages. Additionally, a sedentary lifestyle was reported in 74 adolescents, making up 56.1% of the study. These findings highlight the high prevalence of metabolic abnormalities and unhealthy lifestyle

behaviors, underscoring the multifactorial nature of Non-Alcoholic Fatty Liver Disease (NAFLD) in this population of obese adolescents (Figure 2).

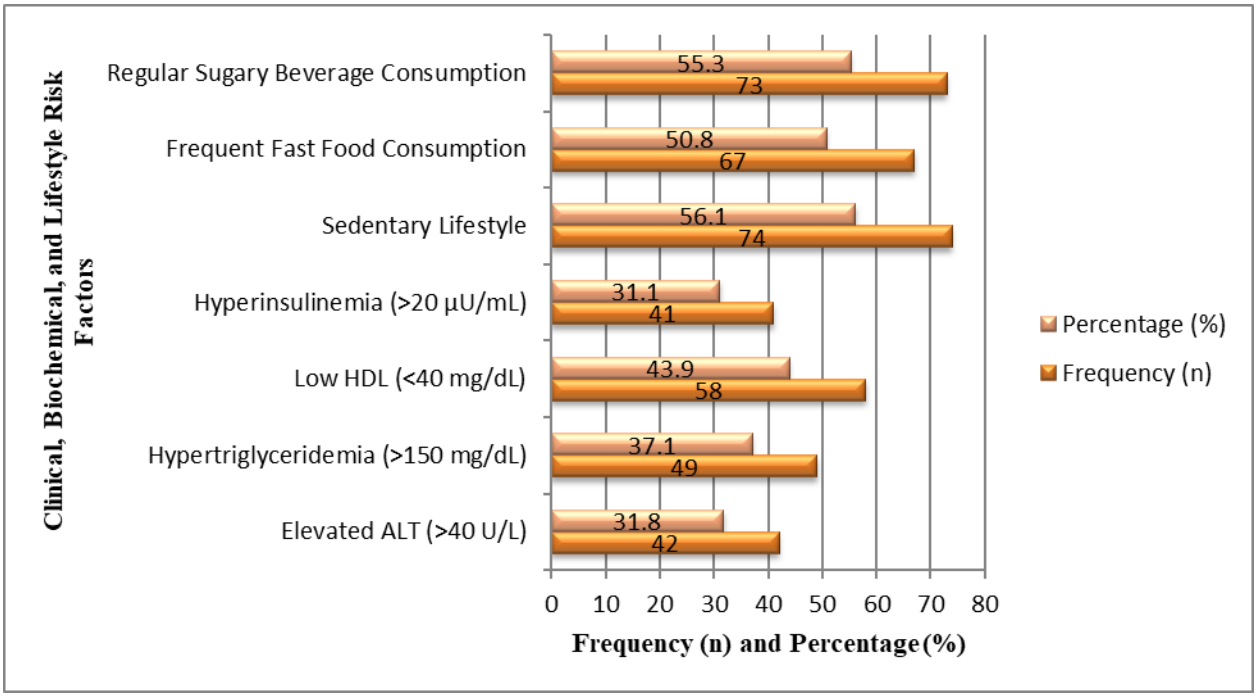

Figure 2: Prevalence of Clinical, Biochemical, and Lifestyle Risk Factors (n = 132)

Discussion

This study revealed a significant frequency of NAFLD in 46.2% of obese adolescents visiting a tertiary care center. Several clinical, biochemical, and lifestyle-related predictors were found to be significantly associated with NAFLD, including high BMI, elevated ALT, hypertriglyceridemia, hyperinsulinemia, and a sedentary lifestyle. These findings highlight the association between metabolic disturbances and lifestyle behaviors with NAFLD, though causality cannot be inferred due to the cross-sectional design.

The observed prevalence of NAFLD in this study aligns with global trends, where studies have reported prevalence rates between 30% and 50% among obese children and adolescents [13]. Similar studies conducted in South Asia have also found comparable prevalence levels, indicating that the burden of NAFLD is increasingly becoming a public health concern in low- and middle-income countries due to rising childhood obesity rates [14].

The association of elevated ALT with NAFLD in this study mirrors findings in multiple cross-sectional and cohort studies that regard ALT as a non-invasive surrogate marker of hepatic steatosis [15]. However, it is noteworthy that ALT alone is not always a sensitive marker and can be normal in early stages of NAFLD [16]. The high frequency of hypertriglyceridemia and low HDL in the NAFLD group supports the concept that NAFLD is a hepatic manifestation of metabolic syndrome, as consistently reported in earlier literature [17].

Furthermore, this study confirmed a strong correlation between hyperinsulinemia and NAFLD, reinforcing the role of insulin resistance in hepatic fat accumulation. Previous data have consistently shown insulin resistance to be a central mechanism in the development of NAFLD, even in pediatric populations [18]. Moreover, the comparable NAFLD prevalence between boys and girls despite expected hormonal and metabolic differences suggests that common environmental exposures, dietary behaviors, and sedentary habits may outweigh sex-specific physiological factors during adolescence [19]. The role of a sedentary lifestyle and poor dietary choices, such as frequent intake of fast food and sugary beverages, was also evident in this study and

is well-supported by the international literature, which attributes lifestyle factors as modifiable contributors to pediatric NAFLD [20].

Limitations and Future Suggestions: This study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other regions and healthcare settings. The cross-sectional nature of the study also limits causal inference. Ultrasound, while widely used, is operator-dependent and may miss early or mild fatty infiltration. Additionally, recall bias is possible due to reliance on self-reported physical activity and dietary intake data. Future research should focus on multicenter, longitudinal studies with larger and more diverse populations, incorporating more sensitive diagnostic tools such as MRI or liver biopsy where feasible. Additionally, intervention-based studies assessing the impact of lifestyle modifications in reversing or halting disease progression in adolescents with NAFLD are strongly recommended. Future studies should consider incorporating liver elastography (FibroScan) to enhance diagnostic accuracy. School-based screening programs and structured nutritional education interventions should also be explored.

Conclusion

This study highlights a high frequency of NAFLD among obese adolescents, with nearly half of the participants affected. Significant predictors included elevated BMI, abnormal liver enzymes, dyslipidemia, hyperinsulinemia, and sedentary lifestyle patterns. These findings underscore the urgent need for early screening, preventive strategies, and lifestyle interventions in obese adolescents to mitigate the long-term consequences of NAFLD. Addressing these risk factors through public health awareness and targeted clinical programs can play a critical role in reducing the burden of NAFLD in this vulnerable population. Policymakers should consider school-based BMI screening and subsidized physical activity programs. ALT combined with ultrasound may serve as a feasible low-cost diagnostic bundle for early detection in resource-limited settings.

Authors' contributions

TN: conceptualization and supervision; methodology; investigation; writing—original draft; critical revision of the manuscript; final approval. RA: methodology; data collection; investigation; writing—original draft; critical revision of the manuscript; final approval. ZAK: data collection; data analysis; writing—original draft; critical revision of the manuscript; final approval. TN: data analysis; methodology; critical revision of the manuscript; final approval. ZEHRAAK: data collection; writing—review and editing; critical revision of the manuscript; final approval. All authors contributed to drafting and critically revising the manuscript; approved the final version for submission; and agree to be accountable for all aspects of the work.

Conflict of interest

The authors declared no conflict of interest.

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