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Exploratory Analysis of Associations Between Body Weight Status, Lipid Profile, and Lifestyle Factors in School-Aged Children in a Developing Country

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Abstract

Objective: To investigate the associations between body weight status and anthropometric parameters, lipid profile, eating behavior characteristics, and physical activity levels among children in a developing country. Methods: The study included 80 children aged 7–11 years, divided into two groups: children with normal body weight (n = 40) and children with overweight or obesity classified using WHO BMI-for-age growth reference standards (overweight >+1 SD, obesity >+2 SD). BMI, waist circumference, and lipid profile (total cholesterol, LDL, HDL, triglycerides) were measured. Eating behavior characteristics and physical activity levels were assessed using standardized questionnaires. Statistical analysis included descriptive statistics, comparative tests, correlation analysis, and exploratory regression models. Results: Children with increased body weight had significantly higher BMI, waist circumference, and a more unfavorable lipid profile ($p < 0.01$). BMI showed a positive correlation with food enjoyment, emotional overeating, and eating speed, and a negative correlation with satiety responsiveness and food fussiness. Lower physical activity levels were associated with higher BMI and higher total cholesterol in unadjusted analyses. Conclusions: Excess body weight among children in a developing country is associated with metabolic and behavioral characteristics in this sample. Given the cross-sectional design and limited sample size, findings should be interpreted as exploratory. The findings highlight associations between body weight status, metabolic parameters, eating behavior, and physical activity, without implying causality due to the cross-sectional design.

Keywords: children; overweight; lipid profile; dietary habits; physical activity; developing country

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1. Introduction

Overweight and obesity in children represent an increasing public health problem worldwide, including developing countries. According to the World Health Organization (WHO), the global prevalence of obesity among children and adolescents has continuously increased over the past decades, with significant consequences for both physical and mental health [1,2]. Childhood obesity is associated with a higher risk of metabolic disorders,

including type 2 diabetes, dyslipidemia, hypertension, and non-alcoholic fatty liver disease (NAFLD), as well as psychosocial problems [2].

Body mass index (BMI) and waist circumference are commonly used anthropometric indicators for assessing obesity and body fat distribution in children, while blood lipids represent key markers of lipid metabolism and cardiometabolic risk [3–5]. The association between body weight, eating behavior characteristics (assessed by questionnaire instruments), and lipid parameters highlights the complex etiology of excess body weight, in which genetic, behavioral, and lifestyle factors interact. Several studies have demonstrated that childhood obesity is accompanied by marked changes in the lipid profile, including elevated low-density lipoprotein (LDL) and triglycerides and reduced high-density lipoprotein (HDL) cholesterol, representing early indicators of cardiovascular disease in adulthood [3,6,7].

Eating behavior, including emotionally driven and hedonic eating, food selectivity, and satiety responsiveness, has a significant association with body weight and lipid metabolism. Studies indicate that children who better recognize physiological satiety signals tend to have lower BMI and a more favorable lipid profile, whereas chronic emotional overeating or greater enjoyment of food correlates with higher BMI and elevated LDL cholesterol [8,9].

Physical activity is an additional factor that significantly influences body weight status and lipid parameters. Reduced physical activity is associated with higher BMI, increased waist circumference, and an unfavorable lipid profile, whereas more active children demonstrate more favorable anthropometric and metabolic indicators [7].

Considering these findings, the aim of this study was to examine the association between anthropometric parameters, lipid profile, dietary habits, and physical activity levels among school-aged children in a developing-country setting. Despite extensive evidence linking obesity with metabolic and behavioral factors in children, there is limited data integrating anthropometric, biochemical, and behavioral variables within a single pediatric population in developing-country settings.

2. Materials and Methods

2.1. Sample and Study Design

The study was conducted on a sample of 80 school-aged children, aged 7–11 years, in a developing country. The children were divided into two equal groups: the first group included children with increased body weight status defined according to WHO BMI-for-age z-scores (overweight and obesity: >+1 SD and >+2 SD, respectively), while the control group included children with normal body weight defined as BMI-for-age z-score between −2 SD and +1 SD according to WHO growth standards. The groups were homogeneous by sex, with 40 boys and 40 girls. All participants lived with both parents, and the average socioeconomic status of the families was reported based on parental self-report and categorized as middle to high. Hypertension and other comorbidities were recorded as categorical variables based on parental-reported medical history and were used only for descriptive baseline characterization.

2.2. Anthropometric Measurements

Body weight and height were measured using standardized procedures, and body mass index (BMI) was calculated based on the obtained values. Participants were classified into two groups according to BMI-for-age z-scores using WHO 2007 growth reference standards (children aged 5–19 years). Waist circumference was measured using a flexible measuring tape according to standardized WHO protocols [10].

2.3. Assessment of Lipid Status

The lipid profile included measurements of total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides from venous blood samples collected in the morning after overnight fasting. Analyses were performed using standard laboratory methods in accordance with relevant clinical laboratory standards. Lipid parameters were additionally interpreted using age-specific pediatric cut-off values according to NHLBI guidelines for pediatric guidelines [11].

2.4. Assessment of Dietary Habits

Children's dietary habits were assessed using the standardized CEBQ (Children's Eating Behavior Questionnaire) [12], completed by parents using a five-point Likert scale. CEBQ was used to assess eating behavior characteristics rather than direct dietary intake or dietary composition The questionnaire comprises eight validated dimensions: food responsiveness, enjoyment of food, emotional overeating, desire to drink, satiety responsiveness, slowness in eating, emotional undereating, and food fussiness. Negatively worded items were recorded according to the questionnaire instructions, after which mean values were calculated for each dimension, forming eight behavioral variables. These variables were analyzed as behavioral eating traits potentially associated with anthropometric and metabolic outcomes.

2.5. Assessment of Physical Activity

The level of physical activity was assessed using the Physical Activity Questionnaire for Children (PAQ-C) on the frequency and duration of physical activities in daily life [13]. Children were classified into three groups: sedentary, moderately active and highly active. No objective measurement tools (e.g., accelerometry) were used, and results should therefore be interpreted as self-reported physical activity levels.

2.6. Statistical Analysis

Descriptive statistical parameters (means and standard deviations) were used for data analysis, while differences between groups were analyzed using the independent samples t-test and ANOVA for multiple groups. Pearson's correlation analysis was used to examine relationships between anthropometric, lipid, and dietary variables, after assessment of data distribution. Given the cross-sectional design and sample size, multiple regression analyses were performed in an exploratory manner to examine associations between variables rather than predictive effects. Statistical significance was set at $p < 0.05$.

2.7. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki of the World Medical Association, the principles of Good Clinical Practice of the International Council for Harmonization, as well as the Law on Scientific Research Activity of the Republic of Serbia (Official Gazette of the RS, No. 110/2005, 50/2006–corr., 18/2010, and 112/2015). The study was approved by the Ethics Committee of the University Clinical Center of Kragujevac (No. 01/25-361, dated 30 May 2025). Written informed consent was obtained from the parents of all participants, with strict adherence to the principles of confidentiality and the right to privacy.

3. Results

3.1. Sample Characteristics

The study included 80 school-aged children, divided into two groups: (1) children with increased body weight status defined according to WHO BMI-for-age z-scores (overweight

and obesity defined as >+1 SD and >+2 SD, respectively) and (2) a control group with normal body weight defined as BMI-for-age z-score between −2 SD and +1 SD according to WHO growth standards, with 40 participants in each group. The groups were homogeneous by sex, including an equal number of boys and girls. The most represented age was 11 years (38.8%), while the smallest proportion of children was aged 7 years (7.5%). All children lived with both parents, all of whom were employed, and half of the families were characterized by a middle-to-high standard of living. Half of the parents had a university degree (50%), while 41.3% had a college-level education. Family history indicated a high prevalence of genetic predisposition to obesity (73.8%) and the presence of hyperlipidemia (53.8%). Among chronic diseases, hypertension was the most common (52.5%), whereas cardiovascular diseases were present in 15% and diabetes in 5% of participants (Table 1). These conditions were recorded based on medical history data as part of the baseline assessment. The study was conducted in Kragujevac, Serbia, a middle- to lower-income country with a generally lower standard of living compared with high-income European countries. Participants were recruited from local primary schools using a convenience sampling approach. Inclusion criteria included age between 7 and 11 years and absence of chronic diseases affecting growth, metabolism, or lipid profile.

Table 1. Basic Characteristics of the Sample—Sex, Age, Socioeconomic Status, and Chronic Diseases.

Category/Subcategory		*n*	%	Cumulative %
Group	Increased body weight status	40	50%	50
	Control group	40	50%	100
Sex	Male	40	50%	50
	Female	40	50%	100
Age (years)	7	6	7.5%	7.5
	8	11	13.8%	21.3
	9	13	16.3%	37.5
	10	19	23.8%	61.3
	11	31	38.8%	100.0
Living with both parents		80	100	100%
Parental education level	Secondary school	7	8.7%	8.8
	College	33	41.3%	50
	University degree	40	50%	100
Parental employment status	Employed	80	100%	100
Monthly household income	Lower-middle	23	28.8%	28.8
	Upper-middle	43	53.8%	82.5
	High income	14	17.5%	100
Family history of obesity	Yes	59	73.8%	73.8
	No	21	26.2%	100
Family history of hyperlipidemia	Yes	43	53.8%	53.8
	No	37	46.2%	100
Physical activity level	Sedentary	6	7.4%	7.5
	Moderate	43	53.8%	61.3
	Active	31	38.8%	100
Total		**80**	**100**	

Note: Participants were classified into two groups according to WHO 2007 BMI-for-age z-scores: increased body weight status (>+1 SD) and control group (−2 SD to +1 SD).

3.2. Anthropometric Parameters

No statistically significant difference was observed in body height between the two groups, whereas children with increased body weight status had significantly higher mean body weight and BMI. Waist circumference was also significantly greater in children with increased BMI status, compared with the control group (Table 2).

Table 2. Anthropometric parameters: body height, body weight, BMI, and waist circumference (expressed as mean ± standard deviation).

Parameter	Group	*n*	Mean ± SD
Body height (cm)	Increased body weight status	40	147.23 ± 12.39
	Control group	40	146.43 ± 13.08
Body weight (kg)	Increased body weight status	40	62.58 ± 15.02
	Control group	40	45.58 ± 10.86
BMI (kg/m^2)	Increased body weight status	40	28.58 ± 4.10
	Control group	40	20.94 ± 2.20
Waist circumference (cm)	Increased body weight status	40	73.48 ± 14.43
	Control group	40	62.85 ± 10.50

Note: Participants were classified into two groups according to WHO 2007 BMI-for-age z-scores: increased body weight status (>+1 SD) and control group (−2 SD to +1 SD).

3.3. Lipid Profile

Children with increased body weight status (WHO BMI-for-age z-score > +1 SD) had significantly higher total cholesterol, LDL cholesterol, and triglyceride levels, while HDL cholesterol was significantly lower compared to the control group (Table 3).

Table 3. Lipid profile parameters: total cholesterol, LDL, HDL, triglycerides (mean ± SD).

Parameter	Group	*n*	Mean ± SD
Total cholesterol (mmol/L)	Increased body weight status	40	5.29 ± 0.84
	Control group	40	3.78 ± 0.88
LDL (mmol/L)	Increased body weight status	40	3.66 ± 0.52
	Control group	40	2.23 ± 0.56
HDL (mmol/L)	Increased body weight status	40	0.89 ± 0.32
	Control group	40	1.32 ± 0.32
Triglycerides (mmol/L)	Increased body weight status	40	1.85 ± 0.54
	Control group	40	1.02 ± 0.53

Correlation Between Anthropometric and Lipid Parameters

Pearson's correlation analysis was applied to examine the relationships between anthropometric (BMI, waist circumference) and lipid parameters. The results (Table 4) indicate a statistically significant association between anthropometric indicators and lipid values in this study population. The strongest positive correlation was observed between BMI and waist circumference (r = 0.772; $p < 0.01$). BMI showed a significant positive correlation with total cholesterol (r = 0.708), LDL cholesterol (r = 0.681), and triglycerides (r = 0.534; $p < 0.01$). In contrast, a moderately strong negative correlation was found between BMI and HDL cholesterol (r = −0.539; $p < 0.01$).

Table 4. Pearson correlation matrix between anthropometric and lipid parameters.

Parameter	BMI	Waist Circumference	Total Cholesterol	LDL	HDL	Triglycerides
BMI (kg/m^2)	1	0.772 **	0.708 **	0.681 **	−0.539 **	0.534 **
Waist circumference (cm)	0.772 **	1	0.547 **	0.512 **	−0.327 **	0.283 *

Table 4. *Cont.*

Parameter	BMI	Waist Circumference	Total Cholesterol	LDL	HDL	Triglycerides
Total cholesterol (mmol/L)	0.708 **	0.547 **	1	0.784 **	−0.317 **	0.486 **
LDL (mmol/L)	0.681 **	0.512 **	0.784 **	1	−0.449 **	0.517 **
HDL (mmol/L)	−0.539 **	−0.327 **	−0.317 **	−0.449 **	1	−0.476 **
Triglycerides (mmol/L)	0.534 **	0.283 *	0.486 **	0.517 **	−0.476 **	1

Note: Statistical significance: * $p < 0.05$; ** $p < 0.01$.

3.4. Dietary Habits

Children with increased BMI had higher mean scores in the "enjoyment of food" dimension compared with the normal-weight group, whereas children with normal body weight had higher mean scores in the "satiety responsiveness" and "food fussiness" dimensions. For the "desire to drink" dimension, children with normal BMI also demonstrated higher mean scores compared with children with increased BMI, while emotional overeating showed higher mean scores in children with increased BMI compared with the normal-weight group (Table 5).

Table 5. Dimensions of eating behavior by group.

Dimension	Group	*n*	Mean ± SD	t	*p*-Value
Food responsiveness	Increased body weight status	40	2.78 ± 0.50	1.096	0.277
	Control group	40	2.66 ± 0.52		
Enjoyment of food	Increased body weight status	40	3.35 ± 0.57	2.308	0.024
	Control group	40	2.99 ± 0.81		
Emotional overeating	Increased body weight status	40	2.91 ± 0.63	1.237	0.220
	Control group	40	2.70 ± 0.85		
Desire to drink	Increased body weight status	40	2.90 ± 0.48	−1.867	0.042
	Control group	40	3.13 ± 0.50		
Satiety responsiveness	Increased body weight status	40	2.72 ± 0.50	−2.644	0.010
	Control group	40	3.06 ± 0.65		
Slowness in eating	Increased body weight status	40	2.51 ± 0.43	−1.094	0.277
	Control group	40	2.68 ± 0.87		
Emotional undereating	Increased body weight status	40	2.97 ± 0.45	1.116	0.268
	Control group	40	2.83 ± 0.63		
Food fussiness	Increased body weight status	40	2.99 ± 0.48	−2.263	0.026
	Control group	40	3.24 ± 0.53		

Note: df = 78 for all comparisons.

Correlation analysis showed that BMI was positively correlated with "food responsiveness" (r = 0.378), "food enjoyment" (r = 0.537), and "emotional overeating" (r = 0.381), while it was negatively correlated with "satiety responsiveness" (r = −0.577), "eating speed" (r = −0.423), and "food fussiness" (r = −0.478). Waist circumference showed similar patterns, with positive correlations with "food responsiveness" (r = 0.519), "food enjoyment" (r = 0.551), and "emotional overeating" (r = 0.443), and negative correlations with "satiety responsiveness" (r = −0.580), "eating speed" (r = −0.591), and "food fussiness" (r = −0.545). BMI was also positively correlated with total cholesterol (r = 0.695), LDL cholesterol (r = 0.759), and triglycerides (r = 0.615), and negatively correlated with HDL cholesterol (r = −0.545), as shown in Table 6.

Table 6. Correlation of eating behavior with BMI and lipid parameters.

Variable	BMI	Waist Circumference	Total Cholesterol	LDL	HDL	Triglycerides	Food Responsiveness	Food Enjoyment	Emotional Overeating	Desire to Drink	Satiety Responsiveness	Eating Speed	Emotional Undereating	Food Fussiness
Confirmed. BMI (kg/m^2)	1.000	0.628 **	0.695 **	0.759 **	−0.545 **	0.615 **	0.378 **	0.537 **	0.381 **	−0.034	−0.577 **	−0.423 **	−0.160	−0.478 **
Waist circumference	0.628 **	1.000	0.452 **	0.501 **	−0.280 *	0.286 *	0.519 **	0.551 **	0.443 **	0.154	−0.580 **	−0.591 **	−0.264 *	−0.545 **
Total cholesterol	0.695 **	0.452 **	1.000	0.852 **	−0.363 **	0.583 **	0.176	0.237 *	0.090	−0.085	−0.341 **	−0.176	−0.075	−0.198
LDL (mmol/L)	0.759 **	0.501 **	0.852 **	1.000	−0.474 **	0.584 **	0.113	0.277 *	0.098	−0.171	−0.308 **	−0.120	−0.002	−0.237 *
HDL (mmol/L)	−0.545 **	−0.280 *	−0.363 **	−0.474 **	1.000	−0.537 **	−0.114	−0.262 *	−0.191	0.073	0.232 *	0.106	−0.013	0.220
Triglycerides	0.615 **	0.286 *	0.583 **	0.584 **	−0.537 **	1.000	0.127	0.256 *	0.167	−0.056	−0.223 *	−0.038	0.025	−0.211
Food responsiveness	0.378 **	0.519 **	0.176	0.113	−0.114	0.127	1.000	0.717 **	0.530 **	0.281 *	−0.629 **	−0.483 **	−0.444 **	−0.646 **
Food enjoyment	0.537 **	0.551 **	0.237 *	0.277 *	−0.262 *	0.256 *	0.717 **	1.000	0.607 **	0.156	−0.732 **	−0.548 **	−0.356 **	−0.629 **
Emotional overeating	0.381 **	0.443 **	0.090	0.098	−0.191	0.167	0.530 **	0.607 **	1.000	0.239 *	−0.603 **	−0.633 **	−0.334 **	−0.529 **
Desire to drink	−0.034	0.154	−0.085	−0.171	0.073	−0.056	0.281 *	0.156	0.239 *	1.000	−0.261 *	−0.231 *	−0.112	−0.360 **
Satiety responsiveness	−0.577 **	−0.580 **	−0.341 **	−0.308 **	0.232 *	−0.223 *	−0.629 **	−0.732 **	−0.603 **	−0.261 *	1.000	0.744 **	0.487 **	0.654 **
Eating speed	−0.423 **	−0.591 **	−0.176	−0.120	0.106	−0.038	−0.483 **	−0.548 **	−0.633 **	−0.231 *	0.744 **	1.000	0.490 **	0.545 **
Emotional undereating	−0.160	−0.264 *	−0.075	−0.002	−0.013	0.025	−0.444 **	−0.356 **	−0.334 **	−0.112	0.487 **	0.490 **	1.000	0.387 **
Food fussiness	−0.478 **	−0.545 **	−0.198	−0.237 *	0.220	−0.211	−0.646 **	−0.629 **	−0.529 **	−0.360 **	0.654 **	0.545 **	0.387 **	1.000

Note: Statistical significance: * $p < 0.05$; ** $p < 0.01$.

3.5. Physical Activity

Children classified as sedentary had higher mean values of BMI, waist circumference, and total cholesterol compared with moderate and active children (Table 7). A statistically significant difference was observed for BMI ($p = 0.001$), waist circumference ($p < 0.001$), and total cholesterol ($p = 0.005$), while no statistically significant differences were found for LDL cholesterol, HDL cholesterol, and triglycerides ($p > 0.05$).

Table 7. Anthropometric parameters and lipid profile according to physical activity level.

Parameter	Physical Activity	*N*	Mean	SD	df	F	*p*
BMI (kg/m^2)	Sedentary	6	32.04	5.72	2	8.253	0.001
	Moderate	43	24.51	4.98			
	Active	31	23.70	3.88			
	Total	80	24.76	5.05			
Waist circumference (cm)	Sedentary	6	90.67	15.76	2	11.128	<0.001
	Moderate	43	66.56	12.40			
	Active	31	66.03	11.08			
	Total	80	68.16	3.63			
Total cholesterol (mmol/L)	Sedentary	6	5.85	1.52	2	5.617	0.005
	Moderate	43	4.29	1.13			
	Active	31	4.63	0.92			
	Total	80	4.54	1.15			
LDL (mmol/L)	Sedentary	6	3.33	1.01	2	0.818	0.445
	Moderate	43	2.85	0.90			
	Active	31	2.99	0.87			
	Total	80	2.94	0.90			
HDL (mmol/L)	Sedentary	6	0.88	0.33	2	1.517	0.226
	Moderate	43	1.09	0.32			
	Active	31	1.17	0.46			
	Total	80	1.11	0.39			
Triglycerides (mmol/L)	Sedentary	6	1.84	0.59	2	1.181	0.312
	Moderate	43	1.39	0.77			
	Active	31	1.43	0.52			
	Total	80	1.44	0.68			

4. Discussion

The results of this study suggest that in this sample of school-aged children in a developing country, overweight is associated with a combination of metabolic, anthropometric, and behavioral factors. These findings indicate a pattern of central adiposity rather than generalized differences in linear growth among children with increased BMI. These findings are consistent with those of Pulgaron et al. [1], who indicate that increased body mass in children is not necessarily associated with differences in height, but that it is a key factor in assessing metabolic risk. Increased waist circumference and BMI in overweight children are in line with previous research emphasizing abdominal obesity as a reliable indicator

of metabolic disorders [6,14]. Vaijravelu et al. [2] emphasize that elevated BMI in children is associated with an increased risk of type 2 diabetes, dyslipidemia, hypertension, and non-alcoholic fatty liver disease, which provides context for the observed anthropometric differences in this study.

Results of the lipid profile showed statistically significant differences between children with normal and elevated body mass, with children with higher BMI having increased LDL, total cholesterol, and triglycerides, along with reduced HDL [3–5]. These findings are indicative of an adverse lipid profile pattern in children with higher BMI, which has also been confirmed by studies by Datana et al. [3] and Al Dhaifalah et al. [7]. Correlation analysis showed a strong positive association between BMI and waist circumference with total cholesterol and LDL, while HDL was negatively correlated, suggesting an association between higher adiposity and lipid parameters in this sample [6,7].

Analysis of eating behavior dimensions shows that children with increased BMI show greater enjoyment of food and a tendency toward emotional overeating, while children with normal BMI better recognize satiety signals and have a more selective approach to food [1,2,5,8,9]. These findings indicate distinct eating behavior patterns associated with body weight status, particularly in hedonic eating and satiety responsiveness. These findings may support further investigation of anthropometric, metabolic, and behavioral markers in pediatric populations.

Physical activity also plays a key role: children with lower activity levels have higher BMI, larger waist circumference, and an unfavorable lipid profile, suggesting an association between lower physical activity and less favorable anthropometric and metabolic profiles in this sample [2,7]. These findings highlight the potential role of physical activity as a behavioral correlate of adiposity and lipid parameters in school-aged children.

Socioeconomic and educational factors of the family also are associated with children's health. Children from families with higher parental education and more stable socioeconomic status tend to exhibit more favorable dietary patterns and higher levels of physical activity [1,2]. These findings suggest that parental education and socioeconomic context may be relevant factors in shaping children's lifestyle behaviors, warranting further investigation in different population settings.

Additional analysis in the context of developing countries shows that a similar pattern of obesity and dyslipidemia exists in these populations. Intervention studies in pediatric populations have reported that parental and school-based approaches targeting eating behavior and physical activity are associated with improvements in anthropometric and metabolic outcomes [15].

Biochemical mechanisms linking abdominal obesity and dyslipidemia are commonly described in the literature as involving insulin resistance, altered lipid metabolism, and increased hepatic VLDL production, which may contribute to elevated LDL and triglyceride levels and reduced HDL in children with higher BMI [16]. Children with pronounced hedonic and emotional eating patterns tend to show less favorable anthropometric and lipid profiles, highlighting the importance of considering eating behavior dimensions such as satiety recognition and self-regulation in the interpretation of these findings [17,18].

In this study, children with higher hedonic and emotional eating scores showed less favorable anthropometric and metabolic profiles. A study examining the relationship between emotional eating and eating habits in children showed that these behaviors correlate with unhealthy diet and higher BMI [19]. Additional studies have also reported associations between emotional eating, dietary patterns, and higher BMI in pediatric populations [20–22].

Children with Down syndrome frequently present with a higher prevalence of overweight and obesity, along with associated metabolic challenges. Evidence suggests that

structured educational programs focusing on nutrition and physical activity are associated with improved weight management outcomes in this population, and that continuous pediatric follow-up remains important throughout development and into adulthood [23].

In addition, in children identified with elevated LDL-C levels (≥95th percentile), particularly in the context of familial hypercholesterolemia, genetic testing confirms the diagnosis in a substantial proportion of cases. Both monogenic variants and polygenic background contribute to phenotypic variability, highlighting the importance of considering genetic and non-genetic factors in the assessment of lipid disorders in pediatric populations [24].

Overall, our results suggest that excess body weight in children is associated with multiple interacting anthropometric, metabolic, and behavioral factors. Dietary patterns are significantly associated with BMI and metabolic risk in children and adolescents [25], while combined lifestyle interventions have been shown to improve anthropometric and metabolic outcomes [26]. In addition, obesity in childhood is influenced by multiple factors, including genetic predisposition and environmental determinants such as gut microbiota, inflammation, and hormonal regulation, as well as behavioral and socioeconomic factors [27,28].

5. Conclusions

In this sample of school-aged children from a developing-country setting, increased body weight status was associated with a combination of anthropometric, metabolic, dietary, and behavioral factors. Children who better recognize satiety signals and demonstrate a more selective approach to food showed more favorable BMI and lipid profiles, while higher scores in hedonic and emotional eating dimensions were associated with less favorable anthropometric and metabolic profiles. Physical activity and parental education were also associated with differences in eating behavior and metabolic parameters. Overall, the findings suggest that anthropometric, metabolic, and behavioral characteristics are interconnected in pediatric populations and may be relevant for understanding body weight status and associated metabolic profiles.

6. Limitations

The present study has several inherent limitations that cannot be fully addressed within the current design. The cross-sectional nature of the study precludes any causal interpretation of the observed associations between anthropometric, metabolic, dietary, and physical activity parameters. The relatively small sample size limits the statistical power and generalizability of the findings and restricts the possibility of performing robust and reliable subgroup analyses. In addition, the sedentary physical activity group included only six participants, which may have reduced the reliability of ANOVA-based comparisons between physical activity categories and should be considered when interpreting these findings. Another limitation is the reliance on questionnaire-based assessment for both dietary habits and physical activity, which does not provide objective measurements and may be influenced by reporting bias. Furthermore, physical activity data were self-reported rather than objectively measured, which may have introduced recall and social desirability bias. Similarly, although BMI classification was based on WHO BMI-for-age z-scores, the use of broad weight-status categories may have reduced the ability to identify more subtle differences across the BMI spectrum. Furthermore, important confounding variables, such as pubertal status and certain hormonal or metabolic determinants, were not available in the dataset and therefore could not be controlled for in the analyses. Additional potential confounders, including parental BMI, detailed dietary intake, genetic predisposition, and other socioeconomic and environmental factors, were not incorporated into the analyses and may have influenced the observed associations. Despite these limitations, the study

provides relevant preliminary evidence on the interrelationship between anthropometric status, lipid profile, and behavioral factors in a pediatric population.

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Abbreviations

The following abbreviations are used in this manuscript:

BMI	Body Mass Index
WHO	World Health Organization
NAFLD	Non-alcoholic fatty liver disease
LDL	Low-Density Lipoprotein
HDL	High-Density Lipoprotein
CEBQ	Children's Eating Behavior Questionnaire

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