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Body Composition, Peak Height Velocity, Cardiorespiratory Fitness And Quality Of Life Of Children With ADHD Symptoms In The School Environment

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Abstract:
Background: *Attention deficit hyperactivity disorder (ADHD) may be related to impairments in health indicators,which could affect the quality of life of children in the school environment.*
Objective: The aim of this study is to identify ADHD symptoms and their association with body composition parameter*s, peak height velocity, and health-related quality of life (HRQoL) in children attending public schools aged between 6 and 12 years.*
Methods: *This is a cross-sectional observational study. A socioeconomic questionnaire, an assessment of signs and symptoms of ADHD (Multimodal Treatment Study-Swanson, Nolan and Pelham-IV - MTA-SNAP-IV), health-related quality of life (PEDsQLM4.0), anthropometric measurements including body mass index (BMI), waist circumference (WC), skinfolds, peak height velocity (PHV), and the 6-minute walk/run test for cardiorespiratory fitness were conducted.*
Results: *Data showed that 29.0% of the participants exhibited symptoms of ADHD, with the majority being female (n=20, 83.3%). Children with ADHD symptoms had higher waist circumference (Δ= +4.27cm, p=0.035), TL (Δ= +3.37cm, p=0.005), and PHV (Δ= +0.62, p=0.014). In terms of BMI classification, 83.0% of children with ADHD were eutrophic (p=0.001). In conclusion: The emotional aspect domain of QoL score was negatively associated with the MTA-SNAP-IV score (β=-0.136, p=0.021).*
Conclusion: *The prevalence of ADHD was high, particularly in girls. Those diagnosed with the symptoms had higher rates of obesity, a greater distance to reach peak height velocity, and greater impairments in the emotional aspect of their quality of life.*
Key Words*:ADHD; Children; Quality of life; Peak height velocity; Obesity.*

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I. Introduction

Attention deficit hyperactivity disorder (ADHD) is classified as a neurodevelopmental disorder characterized by impaired levels of inattention, disorganization, and/or impulsive hyperactivity, as well as functional limitations in effective communication. [1] Studies indicate that ADHD is prevalent in around 8% of school-aged children. [1,2] Children with ADHD, regardless of sex, experience negative impacts on their health-related quality of life (HRQoL), either from the condition itself or from related comorbidities. The HRQoL of children with ADHD are a topic that requires further research. Early detection of symptoms can minimize negative impacts and future problems. [3]

Obesity and ADHD are often associated with eating disorders due to emotional imbalances such as disorganization, inattention, and impulsive hyperactivity.[4] This can lead to compulsive or emotional eating, making obesity a comorbidity of ADHD.[1,4] The bidirectional association between ADHD and overweight/obesity means that obesity can lead to ADHD and vice versa. The study confirmed that Brazilian children have a higher risk compared to the control group.[5,6]

However, drugs used to treat ADHD may impact the growth and development of children, particularly in severe cases of the disorder.[7] Therefore, studies evaluating anthropometric and body composition variables, as well as the health status of children with ADHD, should also incorporate protocols to assess their maturation

status.[8] For instance, peak height velocity (PHV) is a simple parameter to measure and causes less embarrassment than other specific protocols for children and adolescents.[9]

It is important to note that studies on ADHD are primarily conducted in a clinical-hospital setting, which may not accurately reflect the real-life conditions of growth, development, and overall health status of children with ADHD. The objective of this study is to identify the presence of ADHD symptoms and their association with anthropometric parameters of body composition, cardiorespiratory fitness, and HRQoL of children in a school environment.

II. Material And Methods

This is a cross-sectional observational study conducted with children from two public schools (A and B) in Anápolis (GO, Brazil) between May and September 2022. Both male and female children aged 6 to 12 years attending the first phase of elementary school were included. The inclusion criteria were students duly enrolled in the two public schools and those who had already received a diagnosis of the disorder. Exclusion criteria included children with osteoarticular diseases such as amputations and juvenile arthritis, as well as those with respiratory diseases like acute asthma and bronchitis, and/or serious cardiovascular diseases. These conditions were reported by the parents or guardians when completing the sociodemographic data sheet.

A total of 360 children between the ages of 6 and 12 were enrolled in two schools. Parents and children provided consent to participate in the research, and 156 were included. Recruitment was by invitation. During data collection, 74 children did not complete all assessments and were considered losses. Therefore, the analyzed data included 82 children: 48 from School A and 34 from School B (see Figure 1).

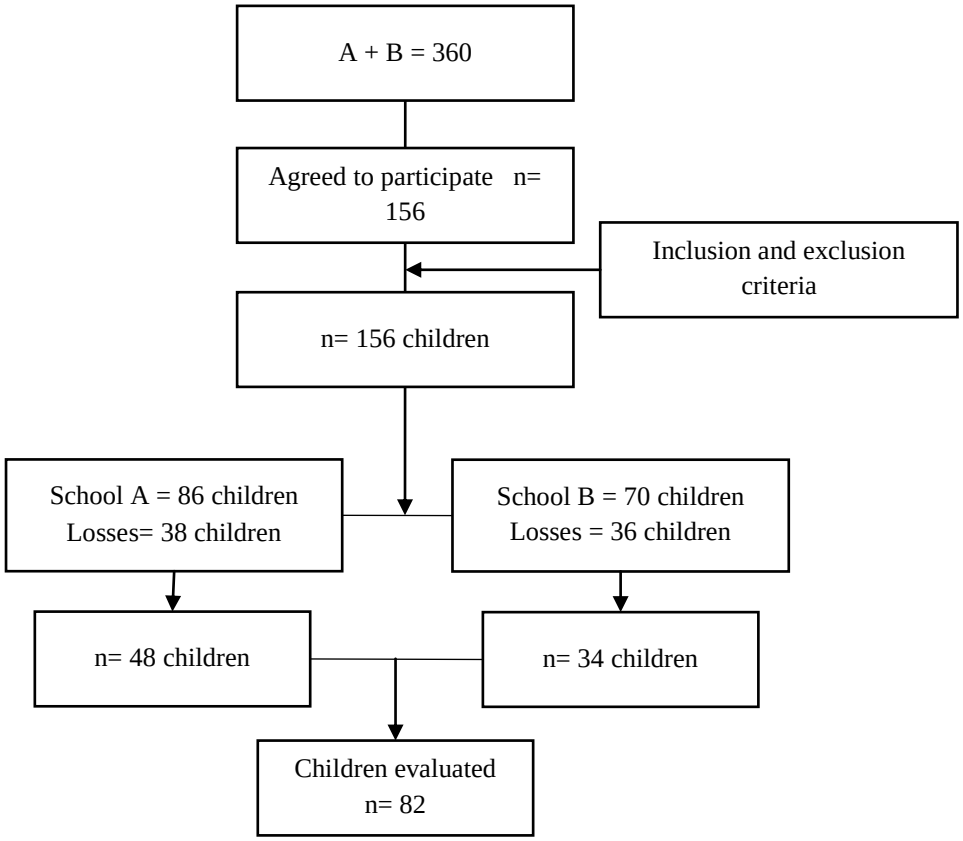

Figure 1. Recruitment flowchart of children who participated in the study.

The post hoc analysis of the sample power was conducted using G*Power software (version 3.1.9.7). The analysis included a comparison between groups and multiple linear regression. The sample consisted of 82 children, with 24 having ADHD and 58 without. The effect size (f^2) mean was 0.15, with a significance level of 5%. One predictor factor and three adjustments (sex, age and PHV) were considered, achieving a power of 83%.

After completing the necessary authorizations, we proceeded to administer the sociodemographic questionnaire, ADHD symptom assessment, and health-related quality of life (HRQoL) questionnaire. We also evaluated anthropometric measurements such as body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHR). Additionally, we obtained the percentage of body fat from skinfold measurements. Cardiorespiratory fitness (CRF) was evaluated using the six-minute walk/run test. Maturity was assessed using

the peak height velocity (PHV) and Tanner Scale, taking into account only menarche for girls and pubic hair for both sexes.

Socio-demographic, ADHD symptoms and quality of life

The questionnaire on socio-demographic characteristics included fundamental information about the child, such as gender, age, education, presence of comorbidities, use of continuous medication, and social class. The assessment of ADHD symptoms was conducted using the Multimodal Treatment Study-Swanson, Nolan and Pelham-IV (MTA-SNAP-IV) questionnaire, which consists of 26 questions. Only the first 18 questions were used to evaluate children with ADHD symptoms based on DSM-5 criteria.[2,10,11] The final score was obtained by summing the points on the questionnaire. Health-related quality of life (HRQoL) was evaluated using the generic PEDsQLTM4.0 questionnaire, which was completed by children aged 5 to 7 and 8 to 12 years old. The participating children themselves answered the questionnaire, which consisted of 28 questions about health, emotions, social life, and school life. A higher score indicates a better health-related quality of life (HRQoL).[12]

Anthropometrics measures

The body mass index (BMI) was calculated by dividing the body mass, measured using a digital scale (Welmy, model LED 200 kg, São Paulo, Brazil), by the square of the height (Sanny®, São Paulo, Brazil).[13] Z-score values were used for BMI classification.[14] Waist circumference was measured using a fiberglass anthropometric tape (Sanny®, São Paulo, Brazil) at the midpoint between the iliac crest and the lower costal margin (12th rib).[14] WC classification was determined based on the 90th percentile for each sex.[15] Triceps and medial leg skinfolds were collected using a plicometer (Lange brand, Cambridge Scientific Industries Inc, Cambridge – USA) with a spring that maintains a constant pressure of 10g/mm² in any opening. The skinfold calculation equations and classification were based on the percentage of fat in children according to age and sex.[16] Waist-to-height ratio (WHR) was determined by dividing waist circumference by height in centimeters, and the classification used the cut-off point for both sexes.[13] Age of peak height velocity (PHV) was calculated using measurements of height (H), body mass (BM), leg length (LL), and sitting height (SH). Equations were used to calculate the age of peak height velocity (PHV). Negative values indicate that children are in pre-PHV, while positive values indicate post-PHV.[9]

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed using the six-minute walk/run test, in a flat location, on a 20-meter track and considering the reasonable classification category according to Gaya and Gaya.[13] The distance covered was measured in meters. For the classification of cardiorespiratory fitness, cut-off points were used according to the child's age, which indicated the increased chance of presenting a cardiovascular risk factor, specific for each sex.[13]

Ethical approval

The study was conducted in accordance with Resolution #466/12 of the National Health Council and the Declaration of Helsinki. It was approved by the Research Ethics Committee of UniversidadeEvangélica de Goiás - UniEVANGÉLICA under number 5.288.646/2022.

Data analysis

The study results were presented using mean, standard deviation, frequency, and percentages. To test for data normality, the Kolmogorov-Smirnov test was used. Children were divided into two groups based on the presence or absence of ADHD symptoms, as determined by the SNAP-IV. Categorical variables were compared using the Chi-square test, while continuous variables were compared using the Student-t and Mann-Whitney tests. The difference between means (Δ) was calculated to better illustrate the variations. Multiple linear regression was used to determine whether anthropometric measurements, cardiorespiratory fitness (CRF), peak height velocity (PHV), and age- and sex-adjusted quality of life (QoL) domains predicted the SNAP-IV score. Cohen's effect size (d) and r were used for variables with normal and asymmetric distribution, respectively. The classification criteria were based on Cohen's (1988) guidelines: 0.1 indicating a small effect, 0.3 indicating a medium effect, and 0.5 indicating a large effect. A p-value of less than 0.05 was considered statistically significant. The data analysis was performed using the Statistical Package for Social Science (SPSS, IBM version 23.0, Armonk, NY).

III. Result

Table 1 describes the sample's characteristics. Children with ADHD symptoms had higher body mass (Δ= + 4.94kg) and height (Δ= + 0.09m). The majority of children with ADHD symptoms were female (83.3%),

had brown skin (62.5%), were in the 4th year of elementary school (50%), and belonged to economic Class C (45.8%). Of the total number of children studied, 24 (29%) exhibited symptoms of ADHD. Regarding the male children, two were receiving methylphenidate hydrochloride treatment, while one had hyperactivity, two had inattention, and one had combined characteristics. Among the 20 girls with ADHD symptoms, two were receiving methylphenidate hydrochloride treatment. Twelve had a predominance of hyperactivity/impulsivity, six had a predominance of inattention, and two had combined characteristics. Among children with ADHD, 9 (37.5%) presented anxiety, 2 (8.3%) had allergic disease, and 1 (4.2%) had hematological disease. It is important to note the comorbidities associated with ADHD.

Table 1. Baseline characteristics of children with and without ADHD symptoms (n=82).

Variables	**Total (n=82)**	**With ADHD symptoms (n=24)**	**Without ADHD symptoms (n=58)**	**p-value***
	Mean±DS	Mean±DS	Mean±DS	
Age (years)	8,65±1.44	9.08±1.32	8.47±1.47	0.078
Weight (kg)	30.64±7.86	34.13±11.03	29.1 ±5.60	0.046
Height (cm)	1.35±0.11	1.41±0.11	1.32±0.09	0.001
Sex		n (%)	n (%)	
Female	46 (56.1)	20 (83.3)	26 (44.8)	0.001
Male	36 (43.9)	04 (16.7)	32 (55.2)	
Ethnicity				
White	25 (30.5)	07 (29.2)	18 (31)	
Black	05 (6.1)	02 (8.3)	03 (5.2)	0.807
Brown	51 (62.2)	15 (62.5)	36 (62.1)	
Yellow	01 (1.2)	0 (0)	01 (1.7)	
Schooling				
1st year	11 (13.4)	02 (8.3)	09 (15.5)	
2nd year	08 (9.8)	0 (0)	08 (13.8)	
3rd year	21 (25.6)	04 (16.7)	17 (29.3)	0.017
4th year	24 (29.3)	12 (50.0)	12 (20.7)	
5th year	18 (22.0)	06 (25.0)	12 (20.7)	
Comorbidity	32 (39.0)	12 (50.0)	20 (34.5)	0.190
Drugs	10 (12.2)	04 (16.7)	06 (10.3)	0.438
Economic class				
A-B	10 (12.2)	04 (16.6)	06 (10.3)	
C-D	54 (65.8)	18 (75.0)	36 (62.0)	0.240
E-F	18 (22.0)	02 (8.4)	16 (27.6)	

Data expressed as mean, standard deviation, frequencies and percentages. ADHD – attention deficit hyperactivity disorder. Comparison of numeric variables – Student-t test. Association between categorical variables – Chi-square test. *Data to $p<0.05$.

Waist circumference (Δ= + 4.27cm), TL (Δ= + 3.37cm), and PHV (Δ= +0.62) were higher in children with ADHD symptoms (Table 2).

Table 2. Comparison of Body Composition, Cardiorespiratory Fitness, Peak Height Velocity, and Quality of Life variables of children with and without signs and symptoms of ADHD (n=82).

Variables	**Total (n=82)**	**With ADHD symptoms (n=24)**	**Without ADHD symptoms (n=58)**	**ES**	**P-value***
Body composition					
BMI (kg/m²)	16.58±2.60	16.84±3.64	16.48±2.05	0.12	0.657
Waist-to-Height Ratio	0.43±0.05	0.47±0.07	0.43±0.04	0.04	0.740
Waist Circumference (cm)	58.50±6.83	61.58±8.36	57.21±5.70	0.23	0.035
Body Fat (%)	20.48±6.25	20.53±6.78	20.46±6.07	0.01	0.965
Triceps Skinfold (mm)	1.77±4.94	11.79±6.04	11.76±4.47	0.03	0.755
Medial Leg Skinfold (mm)	14.13±5.01	13.94±5.20	14.21±4.98	0.05	0.671
Cardiorespiratory Fitness					
Distance traveled (m)	734.85±142.56	773.23±143.61	718.98±140.30	0.16	0.118
Growth					
Peak Height Velocity	-4.45±1.06	- 4.01±0.94	- 4.63±1.06	0.62	0.014
Trunk (cm)	71.20±5.06	73.58±5.55	70.21±4.53	0.26	0.005
Quality of life					
Physical Capacity	82.58±15.77	82.42±11.01	85.65±17.44	0.14	0.219
Emotional Aspect	67.56±20.43	64.17±22.44	68.97±19.57	0.09	0.398
Social Aspect	81.71±19.28	82.29±17.63	81.47±20.07	0.00	0.975
School Activity	72.07±17.43	70.83±18.16	72.59±17.25	0.03	0.777
Score MTA-SNAP-IV	14.62±10.63	26.63±8.93	9.66±6.53	0.68	<0.001

All values are presented as mean (SD). ADHD – Attention Deficit Hyperactivity Disorder, ES- effect size, BMI – body mass index. Student-t or Mann-Whitney test. *Data to $p<0.05$.

The chi-square results (Table 3) showed an association only between BMI and the presence of signs and symptoms of ADHD in the children studied (Table III).

Table 3. Association of Body Composition Variables, Cardiorespiratory Fitness, Growth, and Quality of Life of children with and without symptoms of ADHD (n=82).

Variables	Total (n=82)	With ADHD symptoms (n=24)	Without ADHD symptoms (n=58)	P-value*
Body Composition		n (%)	n (%)	
BMI				
Overweight/obese	04 (4.9)	04 (16.7)	0 (0)	0.001
Body Fat				
Above expected	24 (29.3)	04 (16.7)	20 (34.5)	0.107
Waist-to-Height Ratio				
Above expected		04 (16.7)	04 (6.9)	0.193
Waist Circumference				
Above expected	20 (24.4)	08 (33.3)	12 (20.7)	0.153
Cardiorespiratory Fitness				
Below expected	66 (80.5)	19 (79.2)	47 (81.0)	0.847
Quality of Life				
Physical capacity				
≤ P (50)	46 (56.1)	17 (70.8)	29 (50.0)	0.084
> P (50)	36 (43.9)	07 (29.2)	29 (50.0)	
Emotional aspect				
≤ P (50)	41 (50.0)	13 (54.2)	28 (48.3)	0.627
> P (50)	41 (50.0)	11 (45.8)	30 (51.7)	
Social aspect				
≤ P (50)	55 (67.1)	15 (62.5)	40 (69.0)	0.571
> P (50)	27 (32.9)	09 (37.5)	18 (31.0)	
School activity				
≤ P (50)	62 (75.6)	17 (70.8)	45 (77.6)	0.517
> P (50)	20 (24.4)	07 (29.2)	12 (22.4)	

BMI – Body Mass Index; P (50) – 50th percentile. Chi-square test. *Data for p<0.05.

ADHD symptoms reported by parents on the MTA-SNAP IV questionnaire were inversely related to emotional aspects of children's quality of life (Table 4).

Table 4. Multiple Linear Regression of the MTA-SNAP IV Score (Dependent Variable) with Emotional Aspect (Independent Variable) (n=82).

	MTA-SNAP IV Score			
Parameters	β (IC 95%)	P-value*	β (IC 95%) $_{adjusted}$	P-value**
BMI (kg/m²)	-0.12 (-1,02 / 0,79)	0.801	-0.14 (-1.07 / 0.78)	0.757
Waist-to-Height Ratio	20.04 (-26.54 / 66.62)	0.394	26.55 (-22.94 / 76.03)	0.289
Waist Circumference (cm)	0.25 (-0.09 / 0.59)	0.151	0.42 (-0.46 / 1.30)	0.342
Body Fat (%)	-0.14 (-0.51 /0.24)	0.475	-0.19 (-0.58 / 0.20)	0.325
Distance (m)	-0.00 (-0.02 / 0.01)	0.727	-0.00 (-0.02 / 0.02)	0.685
Physical capacity	-0.12 (-0.26 / 0.03)	0.124	-0.15 (-0.31 / 0.01)	0.058
Emotional aspect	-0.12 (0.23 / -0.01)	0.035	-0.14 (-0.25 / -0.02)	0.022
Social aspect	-0.05 (-0.16 / 0.07)	0.394	-0.07 (-0.21 / 0.06)	0.274
School activiy	-0.06 (-0.19 / 0.08)	0.421	-0.07 (-0.21 / 0.07)	0.323

*Simple linear regression; **Multiple linear regression, adjusted for sex, age, and PHV. Data to P<0,05

IV. Discussion

The study found a high prevalence of ADHD symptoms, which were more common in girls. Children with ADHD symptoms had higher waist circumference and reached peak height velocity at a greater age. The emotional aspect domain of quality of life was negatively affected by ADHD, as indicated by the inverse relationship with the MTA-SNAP IV questionnaire score.

The prevalence of ADHD in this study was high, as compared to the values reported in epidemiological studies (ranging from 6% to 16.3%).[17-19] The increase in the number of cases and persistence into adulthood, requiring continuous medication, may be associated with social and economic factors, such as intense competition among societies (especially among young people) and the influence of the pharmaceutical industry.[17,18,20]

Our study found that a majority of children exhibiting ADHD symptoms were female. However, the literature reports that ADHD is more commonly diagnosed in males[19], with only one study indicating a higher

prevalence in girls.[17] This suggests a wide discrepancy in the ratio of boys/men to girls/women diagnosed with ADHD, which may be due, at least in part, to lack of recognition and/or referral bias for evaluation and follow-up. There appear to be differences in the presentation and evaluation of symptoms, including the influence of comorbidities and associated capabilities.[21] The finding that a higher percentage of girls exhibit ADHD symptoms is noteworthy due to its association with more severe premenstrual symptoms, postpartum depression during the first pregnancy, and the climacteric period in adulthood.[22]

Regarding the higher rates of obesity, particularly in children with ADHD, it is important to note that this increases the likelihood of these individuals becoming obese adults and developing associated cardiometabolic diseases. This, in turn, will have a negative impact on the public health system for future generations. The research indicates that children with ADHD symptoms had a higher mean waist circumference than the group without symptoms, with a significant percentage of cardiovascular risk. A study conducted in Switzerland evaluated over two million people and found that individuals with ADHD had a three times greater risk of obesity compared to those without the disorder. This occurrence has also been reported in other studies. [4,5,23,24] However, the mechanisms contributing to these findings are not fully understood. There is evidence of a bidirectional relationship between obesity and ADHD. [5,24] The present study suggests that the higher waist circumference values may be related to the fact that only four children were undergoing drug treatment, as the drugs have the effect of increasing satiety.

The study found that the evaluated children were in pre-PHV, as indicated by their negative average PHV. Additionally, children with ADHD symptoms had the highest negative values. A study in the literature evaluated the effect of methylphenidate, the most common drug used to treat ADHD, on height and PHV. The study found no significant differences when compared to the control group without ADHD.[8] The assessment according to the Tanner Scale showed that most of the children were not yet in the puberty stage, indicating that all children were in the pre-PHV phase, except for one girl with ADHD symptoms who had already reached menarche. Menarche marks the end of the puberty phase, which is a transitional period to adolescence. It occurs when a child reaches 95.5% of their final height and is always in the post-PHV phase, signifying sexual maturation in females.[25]

To our knowledge, only a few studies have evaluated the perception of quality of life (QoL) in children with ADHD symptoms.[26] In this study, the children themselves provided their perception of QoL.[4] The QoL domains did not differ between the two groups. However, the linear regression analysis revealed an inversely proportional relationship between the MTA-SNAP IV questionnaire score (dependent variable) and the emotional aspect domain (independent variable). Therefore, studies published in the literature consistently show that children with ADHD symptoms report worse emotional quality of life compared to control and/or healthy groups.[3,19, 27] Furthermore, recent studies evaluating health-related quality of life in children with ADHD since 2008 have demonstrated the disorder's negative impact on emotional aspects, including poor school performance, psychosocial factors, social inability, and motor/executive proficiency. [19, 26, 27]

Although the study provides important information about children with ADHD symptoms, it has some limitations. These limitations include the small sample size due to parents' resistance to authorize their child's participation and lack of adherence to carrying out the assessments. Despite presenting the terms of consent to the mothers, fathers, and guardians, many refused to participate due to the environment of misinformation prevalent in society during this period, particularly regarding vaccines and health protocols. This refusal was mainly observed among those who displayed signs and symptoms of ADHD.

The SNAP-IV was validated for parents to self-administer, which may have influenced subjective perception and responses. One of the strengths of this study is that it was conducted in a school environment, which is a departure from previous studies that were conducted in hospital clinical settings. The decision to conduct research with children in a school environment was deliberate, as it is the environment where children spend the most time after home and is therefore the most familiar to them. The topic of ADHD leads to discussions about inclusion and improving the quality of life for students with this condition in the school environment. It is also important to ensure that they receive specialized care at school.

V. Conclusion

The prevalence of ADHD in the evaluated municipal schools was high, particularly among girls, although a higher proportion was expected in boys. Children with ADHD had the highest rates of obesity, were further away from reaching peak growth velocity, and had greater impairments in the emotional state domain of quality of life. These findings suggest the need to pay attention to girls as well, as symptoms can persist into adulthood. Simple, validated, and low-cost measures were used in this study. These measures can be easily included in programs for monitoring children in their school environment. Additionally, it is important to prevent the rise of obesity among children at this stage of development. Research has shown a bidirectional relationship between ADHD and obesity.

Regarding the emotional well-being of children, schools can provide specialized care available in public schools to minimize any negative impact on their development, psychosocial interaction, and overall quality of life. Further work is required in the school environment to identify children exhibiting symptoms of ADHD, as well as those displaying signs of obesity and impaired quality of life. This will enable the development of effective strategies that can lead to sustained long-term results.

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