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Research Article

Comparative Evaluation of Waist Circumference, Waist-to-height Ratio and BMI for Predicting Obesity in Adolescents in Niamey, Niger

Garba Balarabe Maimouna[1, *], Almou Abdoulaye Alio[1], Salifou Alkassoum[2], Adehossi Eric[2], Sabo Seini Haoua[1], Sadou Hassimi[1]

[1]Departement of Chemistry, Abdou Momoumouni University, Niamey, Niger

[2]Departement of Medecine and Medical Specialy, Abdou Moumouni University, Niamey, Niger

Abstract

Overweight and obesity during adolescence are a global public health concern due to their potential impact on health and their increasing prevalence. The aim of this study is to determine the contribution of waist circumference and BMI in predicting obesity among adolescents attending public and private schools in Niamey (Niger). This is a descriptive cross-sectional study involving secondary school students aged 11 to 17. The survey is conducted from 1 April to 30 June 2021. For each student, weight, height and waist circumference were measured, and body mass index (BMI) and waist-to-height ratio were calculated. The 420 students enrolled, 193 were girls, giving a sex ratio (boys/girls) of 1.17. The average weight is 47.69 ±13.71kg. The average weight of girls is 49.66 ±13.57, ranging from 20 to 121kg. The average weight of boys is 46.01 ±13.62, ranging from 22 to 129.4kg. In girls, waist circumference increases between the ages of 12 and 15, from 60.90 ±12.93cm to 64.41 ±11.94cm, peaks at age 16 (67.38 ±9.58cm) and then decreases to 65.81 ±8.62cm at age 17. Among boys, the trend is also upward between the ages of 12 (58.63 ±5.63cm) and 17 (63.75 ±8.55cm). The waist-to-height ratio decreases between the ages of 12 and 17, with a rebound at age 16 for both girls and boys. In boys, the WHtR decreases from 0.44 ±0.00 at age 12 to 0.39 ±0.04 at age 15, rises to 0.41 ±0.05 at age 16 and then falls to 0.39 ±0.05 at age 17. The decrease in WHtR during adolescence is very significant (p=0.02). Girls are 2.35 times more likely to be overweight than boys (p=0.29). Overweight is a public health problem among adolescents in schools. It would be beneficial to integrate nutrition education into school curricula at an early stage. This could be an effective strategy with a long-term impact on reducing the prevalence of obesity and other non-communicable diseases in Niger.

Keywords

Obesity, Overweight, BMI, Waist Circumference

1. Introduction

Obesity is a global public health problem [1, 2]. The prevalence of childhood obesity continues to rise and is increasingly affecting developing countries. Childhood obesity raises con-

*Corresponding author: balarabemaimou@gmail.com (Garba Balarabe Maimouna)

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cerns about obesity in adulthood and is responsible for a considerable increase in cardiovascular morbidity and mortality [3, 4]. More than half of the adult population is expected to be overweight or obese by 2030 [5]. According to the latest WHO report in 2022, 37 million children under the age of 5 were overweight [5]. Among children and adolescents aged 5 to 19, more than 390 million were overweight and 160 million were obese [5]. As adolescence is a key period of development, excess body fat during this phase can have lasting repercussions on physical and mental health. Among the anthropometric indicators used to assess obesity, waist circumference is increasingly considered a relevant marker of abdominal adiposity and cardiometabolic risk [6, 7]. Unlike body mass index (BMI), which does not differentiate between fat mass and lean mass, waist circumference provides a more direct estimate of visceral fat, which is associated with an increased risk of metabolic diseases such as type 2 diabetes and hypertension [8].

In adolescents, changes in waist circumference are influenced by various factors, including eating habits, physical inactivity, socioeconomic status and genetic determinants. Therefore, monitoring waist circumference, in addition to BMI, appears to be an essential tool for the early detection of abdominal obesity and the implementation of targeted interventions. This is why the present study aims to analyse the contribution of waist circumference and BMI in predicting obesity.

2. Methodology

This is a descriptive cross-sectional study involving secondary school pupils aged 11 to 17, conducted from 1 April to 30 June 2021 in Niamey, the capital of Niger. The study involved female and male pupils from public and private secondary schools in municipal districts I and III of Niamey. It is a cluster survey.

2.1. Setting, Population and Type of Study

There are two types of secondary schools in Niger.

- First-level secondary schools or General Education Colleges (CEG), whose pupils are commonly referred to as colleges.

- Secondary schools, whose students are commonly referred to as Secondary school pupils.

This study is conducted in the General Education Colleges (CEG) of the Niamey Urban Community in Niger. It involved secondary school students aged 11 to 17.

This is a two-stage cluster descriptive cross-sectional study. The first stage consisted of the five (05) municipal districts of the Niamey Urban Community, and the second stage consisted of lower secondary schools. The anthropometric parameters of the students were measured. [9] A questionnaire on the parameters assessed is completed by all students participating in the study. A semi-structured interview is conducted on the social stigma of obesity and involved a few students. Data collection took place from 1 April to 30 June 2021.

2.2. Sampling

The urban community of Niamey is subdivided into five municipal districts. We conducted a random draw from a box containing five labels, and two labels were chosen at random, corresponding to districts I and III. Commune I have 54 private French-speaking general secondary schools and 15 public ones, while Commune III has 28 private French-speaking general secondary schools and 11 public ones. As for Franco-Arab secondary schools, Commune I have 9 public establishments and 12 private ones, while Commune III has 9 public establishments and 23 private ones. For each commune, two urns were created, one containing all public and private French-language general secondary schools and the other containing all public and private Franco-Arab secondary schools. In each urn, 10% of the schools were selected at random.

In each school selected at random, all classes at all levels (6th, 5th, 4th, 3rd) were included in the study. In each class, 10% of the students were selected at random to participate in the study.

2.3. Determining Overweight

Two indicators, body mass index and waist circumference, were used to determine the prevalence of overweight and obesity among secondary school students. Overweight is usually defined according to BMI, which is weight divided by height squared, expressed inkg/m^2. BMI = Weight (kg) Height2 (m^2) inkg/m^2. In children aged 5 to 19, BMI is interpreted according to age (growth curves for boys and growth curves for girls).

In this study, the intervals used were underweight (BMI < 3rd percentile), normal (3rd ≥ BMI < 85th percentile), overweight (85th ≥ BMI < 95th percentile), and obesity (BMI ≥ 95th percentile). Overweight corresponds to a BMI for age greater than one standard deviation above the median of the WHO growth reference, and obesity corresponds to a BMI for age greater than two standard deviations above the median of the WHO growth reference [10]. Height is measured using a wall-mounted height rod and weight is measured using a SECA mechanical scale with a weighing capacity of 150kg and an accuracy of 0.1kg.

Waist circumference (WC) and waist-to-height ratio (WHtR) are indicators of abdominal or visceral obesity [11]. WC is measured with a tape measure in the horizontal plane.

2.4. Inclusion/Exclusion Criteria and Ethical Considerations

All students regularly enrolled during the 2020-2021 school year who agreed to complete the questionnaire and interview guide were included in the study.

Students whose date of birth is unknown and students who

were absent on the day of the survey were not included in the study. No biological samples of any kind were collected. No nutritional, dietary, health or biological interventions were carried out. Participation in the study is voluntary. The informed consent of the students was obtained.

2.5. Data Processing and Analysis

Data recording and analysis were performed using the following software: Excel 2010 (Microsoft Corporation, Redmond, USA), SPSS version 2025 IBM Corp (IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp); Stata statistical software, and Epi info 8 (Atlanta Centre for Disease Control and Prevention (CDC)). Univariate and bivariate analyses were performed for in-depth data analysis. The chi-square test is used to compare variables, with a confidence interval of 95% and a p-value < 0.05 for a significant test.

3. Results

Anthropometric characteristics of secondary school students

Table 1. *Anthropometric characteristics mean values of secondary school students in the urban community of Niamey.*

Variables	Total (N = 420)	Gils (N=193)	Boys (N=227)	p-value
Age (ans)	14,84 ±1,49	14,79 ±1,42	14,87 ±1,54	0,590
Weight (kg)	47,69 ±13,71	49,66 ±13,57	46,01 ±13,62	0,006
Waist (m)	1,52 ±0,11	1,52 ± 0,91	1,52 ±0,13	0,944
BMI (kg/m2)	20,26 ±4,59	21,20 ± 5,29	19,46 ±3,73	0,0001
WHtR (cm)	63,96 ±11,77	64,87 ±10,01	62,42 ±9,08	0,0090
Tour de Taille / Taille	0,41 ±0,05	0,41 ±0,06	0,40 ±0,05	0,005

The number in parentheses indicates the number of subjects.

Table 1 presents the anthropometric characteristics of the students. The average age of the students is 14.84 ±1.49 years. The age of the girls ranges from 12 to 17 years and that of the boys from 11 to 17 years. No significant difference was found between the average age of boys and girls (p = 0.59). The average weight is 47.69 ±13.71kg, with girls weighing 49.66 ±13.57kg and boys weighing 46.01 ±13.62kg.

The average height is fairly consistent between the two sexes, at around 152cm (p = 0.94). The shortest height (1.16 m) is measured in girls and the tallest height (1.87 m) in boys. The average BMI-for-age is 20.26 ± 4.59kg/m ². The average BMI-for-age for girls is 21.20kg/m ², which is higher than that for boys, 19.46kg/m ²(p = 0.0001).

The average waist circumference is 63.96 ±11.77cm. The average waist circumference for girls is 64.87 ±10.01cm, which is significantly higher than that for boys, 62.42 ±9.08cm (p = 0.0090). The average waist-to-height ratio is 0.41 ±0.05. It is 0.41 ±0.06 for girls and 0.40 ±0.05 for boys. The difference is significant (p=0.005).

Prevalence of overweight and obesity according to waist circumference among secondary school students.

Table 2 shows the average values of anthropometric parameters and indicators of overweight and obesity according to the gender and age of secondary school students. In the age group studied (11 to 17 years), weight and height increase very significantly (p<0.05). BMI also increases, but especially among girls. Thus, in girls, BMI increases from 19.99 ±6.37 to 23.20 ±4.19 between the ages of 11 and 16, then drops to 21.41 ±5.54 at age 17 (p=0.007). In boys, BMI fluctuates. It decreases from 20.39 ±0.00 to 17.72 ±2.16 between the ages of 11 and 13, rises to 20.91 ±4.92 at age 16, and then decreases to 20.21 ±3.09 at age 17 (p=0.0001).

Waist circumference increases in both boys and girls, but this increase is uneven, reaching a peak at age 16. In girls, waist circumference increases between the ages of 12 and 15, rising from 60.90 ±12.93cm to 64.41 ±11.94cm, peaking at age 16 (67.38 ±9.58cm) and then falling to 65.81 ±8.62cm at age 17. Among boys, the trend is also upward between the ages of 12 (58.63 ±5.63cm) and 17 (63.75 ±8.55cm). However, there are two peaks, the first at age 14 (63.67 ±10.77cm) and the second at age 16 (66.75 ±10.56cm). The increase in waist circumference between the ages of 11 and 17 is very significant (p=0.000) in boys and reaches the threshold of significance in girls (p=0.05).

The waist-to-height ratio decreases between the ages of 12 and 17, with a rebound at age 16 for both girls and boys. In boys, the WHtR decreases from 0.44 ±0.00 at age 12 to 0.39 ±0.04 at age 15, rises to 0.41 ±0.05 at age 16, and then falls to 0.39 ±0.05 at age 17. The decrease in WHtR during adolescence is very significant (p=0.02). In girls, the decrease in WHtR is more mixed and does not reach the threshold of significance between the ages of 11 and 17 (p =0.39). The WHtR

decreases from 0.43±0.06 at age 12 to 0.41±0.08 at age 15, then rises to 0.42±0.60 at age 16 before falling to 0.42±0.06.

Table 2. *Anthropometric parameters and indicators of overweight and obesity mean values (± standard deviation) of of secondary school students in the urban community of Niamey.*

Gender	Age (Ans)	%(N)	Weight (kg)	Waist (m)	BMI (kg/m2)	WHtR (cm)	WHtR/Waist
Gils	12	5,18(10)	38,87±15,75^{a}	139±0,14^{a}	19,99±6,37^{a}	60,90±12,93^{a}	0,43±0,06^{a}
	13	15,02(29)	44,84±14,28^{ab}	149±0,08^{b}	19,98±5,04^{a}	63,83±9,87^{ab}	0,42±0,06^{a}
	14	23,32(45)	48,55±11,67^{bc}	153±0,09^{bc}	20,72±4,11a	63,93±8,51 ^{ab}	0,41±0,05^{a}
	15	21,25(41)	49,46±14,96^{bc}	154±0,08^{c}	20,70±6,77^{a}	64,41±11,94 ^{ab}	0,41±0,08^{a}
	16	21,76(42)	55,74±11,94^{c}	155±0,07^{c}	23,20±4,19^{a}	67,38±9,58^{b}	0,43±0,06^{a}
	17	13,47(26)	51,67±11,18^{bc}	156±0,07^{c}	21,41±5,54^{a}	65,81±8,62 ^{ab}	0,42±0,06^{a}
p-value	--	--	0,0001	0,0002	0,007	0,05	0,39
χ2	--	--	26,50	24,81	15,93	11,05	5,29
Moyenne	14,79±1,42	100(193)	49,66±13,57	1,52±0,91	21,20±5,29	64,87±10,01	0,41±0,06
Boys	11	0,44(1)	35,00±0,00	140±0,00	20,39±0,00	58,00	0,44±0,00
	12	3,52(8)	36,38±9,92^{a}	145±0,17^{a}	17,06±1,21^{a}	58,63±5,63^{a}	0,40±0,03^{a}
	13	21,15(48)	34,54±6,26^{a}	139±0,10^{a}	17,72±2,16^{ab}	58,54±5,55 ^{a}	0,42±0,04^{a}
	14	17,18(39)	5,74±12,26^{b}	152±0,13^{b}	19,66±3,96^{bc}	63,67±10,77 ^{ab}	0,41±0,06^{a}
	15	18,06(41)	6,00±11,87^{b}	153±0,10^{b}	19,36±3,65^{bc}	60,41±7,82 ^{a}	0,39±0,04^{a}
	16	19,82(45)	3,95±16,81^{c}	160±0,11^{c}	20,91±4,92^{c}	66,75±10,56 ^{b}	0,41±0,05^{a}
	17	19,82(45)	52,52±9,19^{bc}	162±0,09^{c}	20,21±3,09^{c}	63,75±8,55 ^{ab}	0,39±0,05^{a}
p-value	--	--	0,00	0,00	0,0001	0,000	0,02
χ2	--	--	88,20	90,74	29,20	39,25	14,99
Moyenne	14,87±1,54	227	46,01±13,62	1,52±0,13	19,46±3,73	62,42±9,08	0,40±0,05
Total	14,84±1,49	420	47,69±13,71	1,52±0,11	20,26±4,59	63,54±9,59	0,41±0,05

The letters (a, b, c) are used to indicate significant differences between frequencies, and in cases of non-significant differences, the same letter is repeated. The numbers in brackets indicate the number of subjects.

The prevalence of abdominal obesity is assessed according to waist circumference (Table 5) and waist-to-height ratio (Table 2). Table 5 shows that the prevalence of abdominal overweight is 6.67% and that of abdominal obesity is 6.43% in the sample. The respective prevalences are 11.40% and 8.29% in girls and 2.64% and 4.85% in boys.

There is approximately 2.5 times more abdominal obesity in girls than in boys (p = 0.004).

Table 3 shows the prevalence of abdominal obesity according to waist-to-height ratio (WHtR) among secondary school students. According to this criterion, 8.57% of students are obese (overweight + obese). The specific prevalences are 12.44% among girls and 5.29% among boys. Girls are 2.35 times more likely to be overweight than boys (p=0.29).

Table 3. *Prevalence of abdominal obesity according to waist circumference (WC) among secondary school students in the urban community of Niamey.*

Gender	Normal	Abdominal Overweight	Abdominal Obesity	Total	p	χ2
Girls	80,31(155)	11,40(22)	8,29(16)	100(193)	0,004	10,99

Gender	Normal	Abdominal Overweight	Abdominal Obesity	Total	p	χ2
Boys	92,51(210)	2,64(6)	4,85(11)	100(227)		
Total	86,90(365)	6,67(28)	6,43(27)	100(420)		

The number in parentheses indicates the number of subjects.

Table 4. *Prevalence of abdominal obesity according to waist-to-height ratio (WHtR) among secondary school students in the urban community of Niamey.*

Genre	Normal	Visceral Overload	Total	p-value	χ2
Girls	87,56(169)	12,44(24)	100(193)	0,29	1,11
Boys	94,71(215)	5,29(12)	100(227)		
Total	91,43(384)	8,57(36)	100(420)		

The number in parentheses indicates the number of subjects.

Body mass index (BMI) is calculated according to the World Health Organisation (WHO) reference curves, and waist circumference is measured directly using a tape measure. The results are shown in Figure 1.

It is observed that 8.8% of students are obese according to BMI, compared to 6.43% according to waist circumference. Similarly, overweight has a high value of 10.5% compared to 6.67% according to waist circumference.

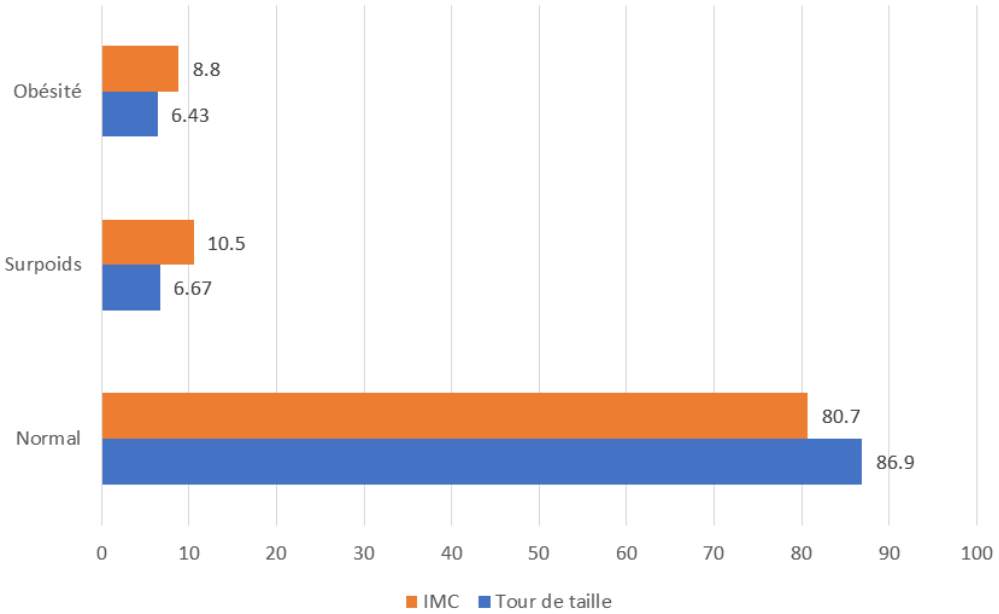

Figure 1. *Comparison between BMI and waist circumference of secondary school students.*

Table 5. *Prediction of obesity based on students' anthropometric variables.*

Variables	Boys	Girls	Total	p-value
Weight	0,944(0,877-1,00)*	0,929(0,88-0,978)*	0,937(0,899-0,974)*	0,000
Waist	0,709(0,592-0,826)*	0,472(0,348-0,596)	0,565(0,474-0,656)	0,191

Variables	Boys	Girls	Total	p-value
PA	0,944(0,884-1,00)*	0,907(0,839-0,975)*	0,921(0,872-0,969)*	0,000
WHtR	0,902(0,819-0,984)*	0,953(0,92-0,986)*	0,939(0,904-0,973)*	0,000
BMI	0,993(0,984-1,00)*	0,978(0,956-0,999)*	0,986(0,976-0,997)*	0,000

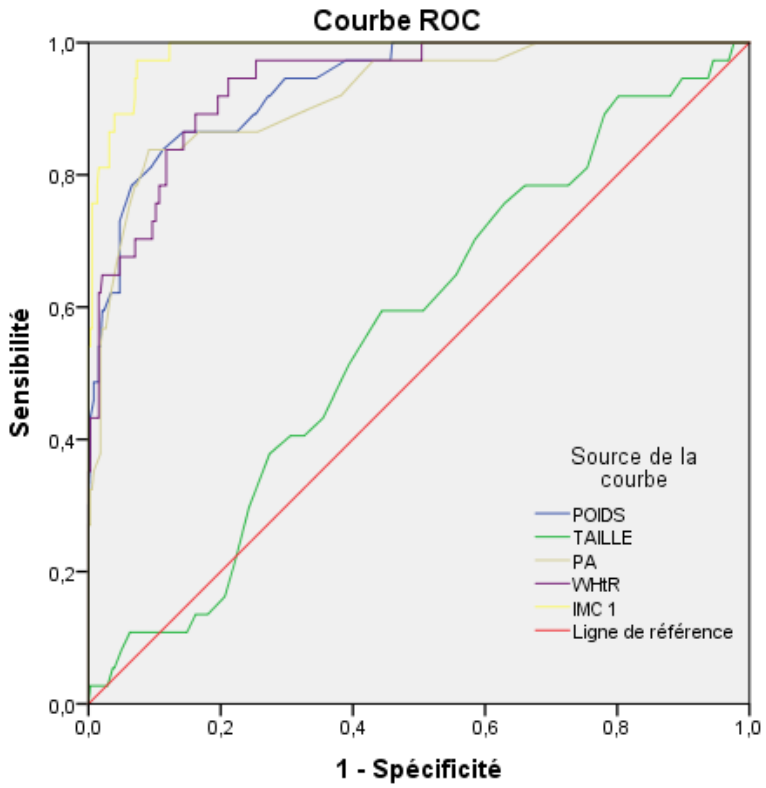

Figure 2. *Prediction of obesity in relation to different variables (weight, height, waist circumference).*

ROC curve analysis shows that the WHtR variable is generally a better predictor of obesity than PA (Figure 1). For this variable, the AUC (Area Under Curve ROC) is slightly higher for female students (0.953) than for male students (0.902). For all the variables used, BMI is a better predictor of obesity, with AUCs tending towards 1 (0.993; 0.978; 0.986 for male students, female students and both sexes overall, respectively). The curve also shows that height is not a variable that can directly predict obesity, with low AUCs and non-significant associations.

4. Discussion

This is a descriptive cross-sectional study involving 420 students, including 227 boys and 193 girls, from 16 public and private schools in the two municipal districts (I and III) of the Niamey Urban Community.

According to the World Health Organisation, obesity has become a major public health problem, even more significant than malnutrition and infectious diseases, and one of the most serious public health challenges of the early 21st century [12-14].

The obesity pandemic and its upward trend do not only affect adults; children and adolescents are also victims [15]. In 2016, more than 340 million children and adolescents aged 5 to 19 were overweight or obese. More than 75% of overweight children live in developing countries [10].

4.1. Anthropometric Characteristics of the Middle School Students Surveyed

The middle school students were aged between 11 and 17, with an average age of 14.84 ±1.49 years. No significant difference is found between the average age of boys and girls ($p = 0.59$). The average age observed in this study is similar to the 14.03 years previously reported among secondary school students in Niamey [15]. It is also close to the average age of Togolese middle school students, 14.36 years. [16] and that of Tunisian middle school students, 14.5 ±2.1 years [17].

In secondary schools, girls predominated, accounting for

61.5% in Dakar, Senegal [18]. 52% in urban schools in Togo [16], 57.3% in Tunisia [17], 52.8% in the municipality of Ashanti-Bekwai in Ghana [19], 53.5% in Lubumbashi in DR Congo [20] and 61.1% in the Cape Province in South Africa. [21] Gender disparities in school attendance and completion rates are therefore not always unfavourable to girls, depending on the country. The average weight of girls is 49.66 ±13.57kg and that of boys is 46.01 ±13.62kg. The difference in weight is significant (p = 0.0063). Among Togolese secondary school students, the average weight is 54.3 ±12.9kg, with girls weighing 53.9 ±12.4kg and boys weighing 54.5 ±13.5kg [16].

In Congo, the weight of secondary school students is 43.78 ±11.62kg, with 42.39 ±12.11kg for boys and 44.95 ±11.04kg for girls [20]. Thus, the average weight observed in this study is between that observed in Congo and that reported in Togo. In Tunisia, the average weight of students is 47.04 ±11.29, with 46.69 ±12.2 for boys and 47.3 ±10.58 for girls. [17].

Body mass index (BMI) is determined using the World Health Organisation's reference thresholds expressed as z-scores [22]. The average BMI is 20.26±4.59, ranging from 12.32 to 54.5kg/m^2. The prevalence of overweight is 10.50% and that of obesity is 8.80%, giving an overall prevalence of 19.30% among the students surveyed. A previous study, conducted in schools in the five municipalities of the city of Niamey, reported a prevalence of 9.5% for overweight and 6% for obesity, giving a combined prevalence of 15.50% [15]. These figures show that overweight and obesity are a serious public health concern among lower secondary school students in Niamey.

In sub-Saharan Africa, in a literature review of 283 articles, the average rates of overweight and obesity among children and adolescents aged 5 to 17 were 10.6% and 2.5% respectively [23]. These values mask disparities between countries. In Ethiopia [24] and the Democratic Republic of Congo [23], in schools and among adolescents aged 10 to 19, the prevalence of overweight is 12.9% and 8% and that of obesity is 2.7% and 1%, respectively. Also in Ethiopia, but in Addis Ababa and among children aged 5 to 19, the prevalence of overweight and obesity is 7.6% and 0.9% respectively [25].

In Senegal, among secondary school students aged 13 to 18, the prevalence of overweight and obesity is 11% and 1.4% respectively [21].

The average height of students is fairly consistent, at around 152cm for both girls and boys. In Congo, the average height of secondary school students is similar to our observations, at 151.30 ±13.09cm, and is also fairly consistent between girls and boys, at 151.38 ±11.58cm and 151.20 ±14.64cm respectively [23]. In Togo, the average height is relatively higher (161cm), and boys appear to be taller (164.4cm) than girls (158.5cm) [16].

The average waist circumference observed in this study is 63.96 ±11.77cm. The average waist-to-height ratio is 0.41 ±0.05. Waist circumference and waist-to-height ratio were higher in girls than in boys.cm).

4.2. Prevalence of Abdominal Obesity According to Waist Circumference

Body mass index is the commonly used marker for measuring obesity in both children and adults. Unfortunately, it does not adequately reflect the distribution of body fat [27]. However, excess abdominal fat has been associated with an increased risk of metabolic and cardiovascular diseases [9, 28]. Waist circumference (WC) correlates fairly well with abdominal obesity in both adults and adolescents [11]. The average WC observed in this study is 63.54 ±9.59cm, with 64.87 ±10.02cm for girls and 62.42 ±9.08cm for boys.

The average waist circumferences observed in this study are lower than the values reported in Brazil [29], Portugal [30] and Quebec [31] for adolescents in the same age group. Our results show that waist circumference increases between the ages of 11 and 17 but fluctuates, with an optimal peak at age 16. This increase in waist circumference during adolescence is consistent with other observations made around the world [29, 32, 33]. A similar observation is made among black adolescents of the same age group in Nigeria, a country bordering Niger. [26] This reversal in WC values could be genetic in origin.

In adults, a WC greater than or equal to 94cm in men and 80cm in women defines abdominal overweight, and a WC greater than or equal to 102cm in men and 88cm in women is associated with abdominal obesity. The prevalence of total abdominal overload of 13.10% recorded in this study falls within the range of 9 to 35% reported by the authors of a critical review of 11 studies conducted in South Africa [34]. According to this study, there is approximately 2.5 times more abdominal overload in girls than in boys. The respective prevalences are 11.40% for abdominal overweight and 8.29% for abdominal obesity among girls, compared to 2.64% and 4.85% among boys, respectively.

This high prevalence of abdominal obesity among girls compared to boys is also observed among South African adolescents, where the prevalence of abdominal obesity is 2% among boys and 13% among girls.

4.3. Prevalence of Abdominal Obesity According to Waist-to-height Ratio

The waist-to-height ratio (WHtR) has also been proposed as a marker for assessing visceral obesity [35-38]. The present study shows that WHtR decreases significantly between the ages of 11 and 17 in boys, while the decreases are much more moderate in girls. Similar observations have been previously reported by various authors [33, 39, 40]. However, other authors have reported a more uneven trend [26, 32, 41].

Finally, identical WHtR values between the two sexes and constant values between the ages of 11 and 17 have also been reported [42]. Our results show that the WHtR of girls at different ages is similar to or higher than that of boys [41, 43].

In adults, a threshold value of WHtR $\geq$ 0.5 has been defined

as an indicator of abdominal obesity in both sexes [39, 44].

In children and adolescents, it has been reported that a WHtR greater than 0.5 is correlated with an increased metabolic risk [39]. It has therefore been suggested that this threshold should also be used in children and adolescents. However, authors have emphasised the need to establish age-related reference thresholds for children and adolescents [45]. Furthermore, as the anthropometric parameters of children and adolescents are subject to variations related to ethnic origin and environmental differences, it would be necessary to define national reference standards for WC and WHtR.

Various countries have defined threshold values and percentiles for WC and WHtR for children and adolescents [46-51]. In the present study, we used the WHtR thresholds defined in Nigerian adolescents aged 10 to 18 years to characterise abdominal obesity [26].

The prevalence of visceral obesity observed in this study is 2.86% in boys and 5.71.44% in girls, for an overall prevalence of 8.57%. This value is close to the 9.2% reported in Cameroon among adolescents of the same age group [52].

In South Africa, significantly higher prevalence rates have been reported. The prevalence of visceral obesity is 21.43%, with a rate of 7.13% among boys and 14.30% among girls [51]. Also in South Africa, according to the authors of a systematic review of 11 studies, the prevalence of abdominal obesity in children and adolescents aged 1 to 20 years, according to the WHtR, ranged from 2.0 to 41.0% [34]. In Turkey, approximately 10.4% of girls aged 12 to 18 were obese at the abdominal level according to the WHtR [54], compared to 12.44% in the present study.

5. Conclusion

This study concluded that there is a high prevalence of overweight among adolescents aged 11 to 17 and identified certain risk factors associated with the development of overweight and obesity at this age. It is important to implement a preventive strategy that includes screening students for overweight, identifying those at risk based on knowledge of risk factors, raising awareness among education professionals, and educating parents in order to correct obesity-promoting habits and establish a healthy lifestyle for the entire family. Particular attention must be paid to this scourge. Nationwide studies are needed to determine the prevalence of childhood obesity.

Abbreviations

BMI	Body Mass Index
CDC	Atlanta Centre for Disease Control and Prevention
WC	Waist Circumference
WHtR	Waist-to-height Ratio

Conflicts of Interest

The authors declare no conflicts of interest.

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