Overweight/Obesity: Prevalence and Epidemiological Profile among High School Students in the District of Bamako

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ABSTRACT

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Introduction: Overweight/obesity constitutes, for non-communicable diseases, a fertile ground that must be fought at all costs. So, this study aimed to describe and document the prevalence of overweight/obesity among high school students in Bamako, based on socioeconomic and demographic characteristics.

Methods: The study was cross-sectional and descriptive. The sample size was calculated using the StatCalc program of the Epi 7.2 software. Data was collected using a questionnaire on KoboCollect. Nutritional status was assessed using the World Health Organization (WHO)-AnthroPlus software and analyzed with SPSS 26 software.

Results: Among 2,400 high school students surveyed, the prevalence of excess adiposity (overweight + obesity) was 17.4% (n=418). High school students were mostly older than 17 years (61.5%). The mean BMI was 21.1 kg/m^2 ± 4.2. Nutritional status differentiated normal BMI (55.3%), thinness (27.3%), overweight (12.0%), and obesity (5.4%). Charcoal was the predominant energy source (76.1%) used for cooking. Regarding sleep quality, 86.6% of students slept less than 8 hours a day. Past tobacco use was reported by 18.1% of high school students, and 8.4% currently used tobacco products. Additionally, 87.8% of students consumed energy drinks. Approximately 86.1% of the overweight/obese students skipped meals. Overweight/obesity was higher in girls (72.7%), students from private high schools (79.4%), and those who did not practice physical activity (88.3%).

Conclusion: The high prevalence (17.4%) of overweight/obesity calls for guidelines for the promotion of good dietary practices among high school students in the district of Bamako.

INTRODUCTION

Excess adiposity (overweight or obesity) has become a serious public health problem worldwide, affecting adults, children, and adolescents. The etiology of this excess adiposity is multifactorial and complex [1]. According to the World Obesity Atlas, the global prevalence of adolescent obesity was 7% in 2022. Three percent of adolescents aged 10-19 are obese in Sub-Saharan Africa, which is going through a nutrition transition characterized by an increasing incidence of excess adiposity and non-communicable diseases [2]. Excess adiposity in adolescents can lead to short and long-term health problems, such as type 2 diabetes, cardiovascular disease, and high blood pressure [3].

The nutritional transition, characterized by profound changes in dietary habits (excess sugar, salt, and saturated fats) with a decrease in daily physical activity, is rapidly increasing in low- and middle-income countries [4]. These changes are associated with obesity and rapidly increase non-communicable diseases (diabetes, cardiovascular diseases, and cancer). In developing countries, urban poor households spend about 70% of their economic resources on food, resulting in a modification of food distribution circuits, with a transition of markets where ultra-processed foods occupy an important place [5].

Adolescence (10-19 years old) is a stage of rapid growth [6] affected by the nutritional transition with the promotion of ultra-processed and fast food [7]. Teenagers are influenced in their food choices by advertisements that promote fast-food-type products [8], through television, the Internet, and cinema [9]. These various factors contribute to the creation of an environment that promotes obesity (obesogenic environment) [1].

In Mali, the epidemiological profile of overweight/ obesity among high school students in the Bamako district is insufficiently documented. It is therefore important to have up-to-date data on overweight/obesity to better guide its preventive and curative management. Thus, this study aimed to assess overweight/obesity prevalence and epidemiological profile among high school students of the district of Bamako.

METHODS

Study design: This was a descriptive, cross-sectional study of public and private high school students, conducted from June 15 to July 4, 2022, in the district of Bamako, the capital of Mali. Bamako City is divided into two banks (Left and Right) by the Niger River, with two corresponding teaching academies controling high schools in the city [10]. Furthermore, the district of Bamako is divided into six (6) communes (I, II, III, IV, V, and VI).

Sample size and procedure: The sample size was calculated using the StatCalc program of the Epi 7.2 software with four parameters: the size of the target population, margin of error of 2%, expected prevalence of 50%, and confidence of 95%, resulting in 2,360 rounded up to 2,400 students.

A multistage stratified sampling technique was employed to select participants. First, using the function (alea) of Microsoft Office Excel, 80 high schools were randomly selected (40 in each academy). Then, in each high school, three classes were selected by a simple random sampling. Finally, in each class, 10 students were selected randomly, stratified according to gender (54% boys and 46% girls).

The criteria for inclusion were threefold: being aged between 10 and 19 years, being enrolled in one of the selected high schools, having agreed to participate in the survey or consent from parents or legal guardians for minors. The sole criterion for non-inclusion was absence on the day of the survey.

Data collection tools and procedure: Anthropometrics used a SECA-type electronic scale to measure weight to the nearest 0.1 kg and a UNICEF-type height rod to measure height to the nearest 0.1 cm. Weight was assessed with light clothing and bare feet on the scale, and height was measured while standing and without shoes.

The KoboCollect app was used to collect the information, and a questionnaire was developed in XLSForm and hosted by the KoboToolbox humanitarian server to facilitate the monitoring of submissions and also to control the reliability of the data collected in real time.

The questionnaire included questions collecting data in five parts: (1) identification of schools (academy and status of high school) and students (age, sex, education level); (2) socio-economic and demographic characteristics; (3) eating habits; (4) physical activity and sedentary leisure; and (5) family history of non-communicable diseases.

Before data collection, 10 interviewers (5 women and 5 men) were selected and trained on the various tools. These investigators were general practitioners and nutrition students with experience in anthropometric and nutritional surveys, as well as a good geographical knowledge of the neighborhoods of Bamako. The two-day training covered the study's objectives, the administration of the questionnaire, anthropometric techniques, and ethical aspects. After the training, a pre-test phase of the questionnaire was conducted, allowing some corrections and clarification of questions.

Data analysis: SPSS version 26 software (IBM, Armonk, New York, USA) was used for cleaning

and analysis.

The World Health Organization (WHO)-AnthroPlus software was used to determine the nutritional status of adolescents through various parameters such as body mass index (BMI), age and sex [11]. The variable of interest in this context pertains to overweight/obesity, which refers to the state where a person has excess adiposity (overweight and obesity). Quantitative variables were presented as mean ± standard deviation, median, and range; qualitative variables were expressed in absolute and relative frequencies.

Ethical considerations: The research protocol was validated by the ethics committee of the University of Sciences, Techniques and Technologies of Bamako (USTTB) (N°2022/127/CE/USTTB). Letters of authorization were issued by the teaching academies of Bamako to allow the investigators access to the selected establishments. The high school students were informed of the objectives and purpose of the research before their selection. The following were obtained: consent for adults and assent, as well as the consent of parents or legal guardians for minors. To guarantee confidentiality, no personal data has been collected.

RESULTS

Sociodemographic profile: The 418 Overweight/obese high school students were predominantly in

Table 1: *Sociodemographic profile of overweight/obese high school students (n=418)*

Variables studied	Terms			
	Yes		No	
	n	(%)	n	(%)
Age ≥ 17 years	254	(60.8)	164	(39.2)
Gender = Girl	304	(72.7)	114	(27.3)
Commune V	108	(25.8)	310	(74.2)
Marital Status = Married	14	(3.4)	404	(96.6)
Lives with parent/guardian/marital home	395	(94.5)	23	(5.5)
Father/guardian Professional status= Employee	196	(46.9)	222	(53.1)
Mother/guardian professional status=Employee	141	(33.7)	277	(66.3)
Number of persons in the house/apartment ≥ 5	381	(91.1)	37	(8.9)
Type of household = Mono/polygamous	315	(75.4)	103	(24.6)
Internet subscription	227	(54.3)	191	(45.7)
Energy cooking = Charcoal/firewood/Gas,	318	(76.1)	100	(23.9)
Computer or tablet	134	(32.1)	284	(67.9)
Smartphone ownership	377	(90.2)	41	(9.8)

Table 2: *Anthropometric parameters and nutritional status of high school students (n=2400)*

Variables studied	Terms
	Mean ± SD
Anthropometric parameters	
Weight	59.9 ± 13.0 kg
Height	1.68 ± 0.1 m
BMI	21.1± 4.2 kg/m^2
Nutritional status	n	%
Thinness	655	(27.3)
Normal BMI	1327	(55.3)
Overweight	288	(12)
Obesity	130	(5.4)

private high schools (79.4%), girls (72.7%), single (96.6%), and under cover of a parent (94.5%). Parents were predominantly self-employed for both fathers (53.1%) and mothers (66.3%). Age, variable from 14 to 19 years, with a mean of 16.9 years ± 1.4, and a median of 17 years, was over 17 years for 60.8% of them. These high school students were predominantly in a family of at least 5 people (91.1%), in a monogamous household (75.4%), with an internet subscription (54.3%), did not own a computer or tablet (67.9 %) but owned a mobile phone (90.2%), and used charcoal as their primary energy source (76.1%) (Table 1).

Prevalence: A total of 2,400 high school students were surveyed. The weight ranged from 30.2 to 132.4kg, with a mean of 59.9 (± 13.0) kg and a median of 57.8 kg. Height ranged from 1.30 to 1.96 m, with a mean of 1.68 (± 0.1) m and a median of 1.67 m. The BMI ranged from 12.1 to 43.8 kg/m^2 with a mean of 21.1(± 4.2) kg/m^2, and a median of 20.2 kg/m^2. The nutritional status differentiated thinness for 655 (27.3%). Over a half (n=1327; 55.3%) had normal BMI, 288 (12%) were overweight, and 130 (5.4%) had obesity, totaling 418 (17.4%) for excess adiposity (Table 2).

Table 3: *Eating and substance use habits of overweight/obese high school students (n= 418)*

Variables studied	Terms			
	Yes		No	
	n	(%)	n	(%)
Eating habits				
Addition of sugar	325	(77.8)	93	(22.2)
Resalting of food	307	(73.4)	111	(26.6)
Snacking	378	(90.4)	40	(9.6)
Meal skipping	360	(86.1)	58	(13.9)
Meal rich in fat	373	(89.2)	45	(10.8)
Consumption of energy drinks	367	(87.8)	51	(12.2)
Tobacco, alcohol and other psychotropic drugs				
Tobacco experience (cigarette)	76	(18.1)	342	(81.9)
Current smoking	35	(8.4)	383	(91.6)
Starting age < 16 years	61	(81.3)	14	(18.7)
Number of cigarettes per day > 2	7	(20.0)	28	(80.0)
Wish to quit	31	(7.4)	387	(92.6)
Alcohol experience	5	(1.2)	413	(98.8)
Current alcoholism	3	(0.7)	415	(99.3)
Age of onset of alcoholism < 17 years	2	(40)	3	(60)
Frequency > 1time/month	2	(0.5)	416	(99.5)
Cannabis Experience	9	(2.2)	409	(97.8)
Current cannabis use	2	(0.5)	416	(99.5)
Cannabis start age < 17 years	5	(55.6)	4	(44.4)
Shisha experience	276	(66.0)	142	(34)
Current shisha consumption	142	(34.0)	274	(66.0)
Other psychotropic products (purple drank)	116	(27.8)	302	(72.2)
Factors contributing to eating and substance use habits				
Family smoking	150	(35.9)	268	(64.1)
Advertising messages	247	(59.1)	171	(49.1)
Awareness messages	60	(14.4)	358	(85.6)
Advertising Influence/Teenagers	369	(88.3)	49	(11.7)

Table 4: *Sleep of overweight/obese high school students (n= 418)*

Variables studied	Terms			
	Yes		No	
	n	(%)	n	(%)
Sleep time per day < 8 hours	362	(86.6)	56	(13.4)
Sleeping troubles	295	(70.6)	123	(29.4)
Sleeping troubles > 3 times per week	143	(34.2)	275	(65.8)
Time in bed before sleep > 30 minutes	300	(71.8)	118	(28.2)
The feeling of having slept badly	249	(59.6)	169	(40.4)
Snoring or difficulty breathing	206	(49.3)	212	(50.7)
Absence from school	63	(15.1)	355	(84.9)
To sleep in class	165	(39.5)	253	(60.5)

Eating habits: The predominant bad dietary practices were of 6 orders: snacking between meals (90.4%), excess of oil in the meal (89.2%), consumption of energy drinks (87.8%), skipping meals (86.1%), adding sugar (77.8%) and resalting food (73.4%) (Table 3).

Consumption of tobacco, alcohol, and other psychotropic drugs: Past tobacco consumption experience was reported by 18.1% of high school students, and 8.4% of them were still smoking. For most, smoking started at the age of 16 (81.3%), with less than three cigarettes a day (80%) and without wishing to stop (92.6%).

Alcohol consumption, experienced by 1.2% of the 418 overweight/obese high school students, was predominantly in private high schools (79.4%). Alcohol consumption began before the age of 17 for 40% and was current for 0.7% of them, with a frequency greater than once a month in 0.5%.

Cannabis consumption, experienced by 2.2% of high school students in the past, was started before the age of 17 for 55.6% and was current for 0.5% of them.

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Table 5: *Physical activity and sedentary of overweight/obese high school students (n= 418*

Variables studied	Terms			
	Yes		No	
	n	(%)	n	(%)
Way to get to school = Motorbike	145	(34.7)	273	(65.3)
Travel time >= 10 minutes	383	(91.6)	35	(8.4)
Practice of physical activity at school	378	(90.4)	40	(9.6)
Practice of physical activity outside of school	49	(11.7)	369	(88.3)
Type of sport/physical activity = Walking	184	(44.0)	234	(56.0)
Frequency per week >= 3	75	(17.9)	343	(82.1)
An environment conducive to physical activity	227	(54.3)	191	(45.7)
Disability / physical activity	79	(18.9)	339	(81.1)
Television: duration > 2 hours on school days	130	(31.1)	288	(68.9)
Television: duration > 2 hours on weekends	339	(81.1)	79	(18.9)
Television/Computer/Tablet > 3 days/week	284	(67.9)	134	(32.1)
Social media/use	367	(87.8)	51	(12.2)
Social media/duration> 2 hours per day	272	(74.1)	95	(25.9)
Video games/habits	191	(45.7)	227	(54.3)
Video games/duration> 1 hour per day	61	(31.9)	130	(68.1)

Table 6: *Psychosocial conditions and family history of diseases of overweight/obese high school students (n=418)*

Variables studied	Terms			
	Yes		No	
	n	**(%)**	**n**	**(%)**
Psychosocial conditions				
Peer influence	204	(48.8)	214	(51.2)
Influenced by family	204	(48.8)	214	(51.2)
Likeness Image = 6	97	(23.2)	321	(77.8)
The image we want to look like = 4	269	(64.4)	149	(35.6)
Ashamed of his current corpulence	280	(67.0)	138	(33.0)
Mockery/stigma overweight	345	(82.5)	73	(17.5)
History of diseases in the family				
Diabetes	246	(58.9)	172	(41.1)
High blood pressure	231	(55.3)	187	(44.7)
sickle cell disease	21	(5.0)	397	(95.0)
Asthma	116	(27.8)	302	(72.2)
Other allergies	85	(20.3)	333	(79.7)

66% in the past of high school students and was current for 34% of them.

Additionally, the following factors were: the influence of advertising (88.3%), advertising messages (59.1%), family smoking (35.9%), the consumption of other psychotropic products (27.8%) and awareness messages (14.4%) (Table 3).

Sleep quality: The mean sleep time for high school students was 6.9 ± 1.0 hours. The median sleep time was 7 hours. Regarding sleep quality, 86.6% of students slept less than 8 hours a day (Table 4).

Physical activity and sedentary lifestyle: The practice of physical activity was very low among girls (5.1%) compared to boys. However, 88.3% (n=369) of overweight/obese high school students did not practice physical activity outside the compulsory physical education and sports sessions at school. Among overweight/obese high school students, 32.1% had a computer or tablet. For internet usage, 87.8% of high school students used social media such as WhatsApp, Facebook, and TikTok (Table 5).

Psychosocial conditions: Among the overweight/obese high school students, 82.5% had experienced stigma because of their corpulence. Regarding their physical appearance, 67.0% of them were

ashamed of their current build; the 4/9 image represented 64.4% of the physical appearance desired by high school students (Table 6).

History of diseases in the families: The histories of diseases found in the families of overweight/obese high school students were respectively 58.9% for diabetes, 55.0% for high blood pressure, 27.8% for asthma, 20.3% for allergies, and 5.0% for sickle cell disease (Table 6).

DISCUSSION

This study aimed to describe the epidemiological profile of overweight/obesity among high school students in the District of Bamako.

The findings showed that the average age of high school students was 16.9 years. Comparable results (16.8 years) were also observed among high school students in the city of Sfax in Tunisia [12]. This trend could be attributed to the particular characteristics of the age group of 15 to 19 years, which constitutes the second phase of adolescence [13], and is marked by significant physiological and behavioral changes. Overweight/obesity was higher among girls (72.7%), which could be explained by the fact that boys are less sedentary than girls. High school students in private schools (79.4%) were more overweight/obese than those in public schools. The results of the study conducted

by Mwaikambo et al. [14], in Tanzania were similar (75.9%) to those in this study. This could be explained by the fact that private high schools have more ultra-processed food outlets, and the socioeconomic level is generally higher compared to public high schools. High socioeconomic status can influence the dietary habits of individuals or households, often leading to diets high in fat, salt, and sugar while being low in fruits and vegetables. This dietary imbalance could influence the body mass index and lead to excess adiposity [15]. Studies conducted in Congo-Brazzaville by Mabiala-Babela et al. [16], and in Nigeria by Ubesie et al. [17] revealed that obesity was more common among adolescents from households with high socioeconomic status. Unlike developed countries, individuals or households of high socioeconomic status are more exposed to ultra-processed foods in developing countries, where the consumption of Western-style foods is considered a sign of wealth and well-being within these societies.

This study also revealed that 87.8% of overweight/ obese high school students consumed energy drinks. These beverages contain significant amounts of sugar and caffeine, which are associated with negative health consequences. Excess sugar found in energy drinks is a risk factor associated with overweight/obesity [18], while the caffeine included in these drinks can lead to dependence among consumers, with marketing campaigns and advertising potentially exacerbating the issue. Brands of soda and energy drinks particularly target the adolescent population through recreational activities in schools or within the community. In addition, the consumption of energy drinks could increase alcohol dependence in adolescents. This trend could be explained by adolescents mixing energy drinks and alcohol to combine the stimulating and relaxing or euphoric effects [19].

We found that snacking rate was very high among overweight high school students (90.4%), which is higher than what was reported in another study conducted by Barry et al. [20], among high school students from Kamsar in Guinea (24%). This disparity could be explained by the specific context in which each study was conducted. The present study was carried out in an urban environment, while that of Barry et al. was conducted in a peri-urban environment, where environmental factors and dietary habits may vary between these two

contexts. Snacking is generally associated with the consumption of ultra-processed foods such as cakes, candies, cookies, sodas, and chips [21]. The nature and habits of snacking can significantly impact health and well-being through all stages of life due to the associated high risk of overweight/ obesity [22]. Each individual's level of physical activity depends on various parameters related to their personal characteristics, environment, and social culture. According to the WHO, more than 80% of adolescents in school do not meet the global recommendations on physical activity. Similarly, 88.3% of overweight/obese high school students in our study did not practice physical activity outside physical education and sports sessions at school. Compared to this study, the results reported by Regaieg et al. [12], were higher (99.0%) among overweight/obese high school students (n=400). This decline in physical activity among adolescents could be explained by spending more on screens (television, internet, video games), but also by a weak promotion of physical activity outside dedicated school training sessions, lack of physical education and sports at school. This calls for the establishment of non-sedentary recreational facilities in various communities designed to encourage physical activity and be accessible to children and adolescents in Mali, especially girls. Without immediate action, the achievement of the global goal to reduce the inadequacy of physical activity to 15% by 2030 could be jeopardized [23]. The practice of regular physical activity could reduce the risk of early mortality by 30 to 60%. In addition, it also helps reduce depression and anxiety [24]. This practice also promotes a better quality of sleep and can help reduce the consumption of unhealthy foods and snacking in children and adolescents [24].

Adolescence is characterized by disruptions in sleep structure that have cognitive, psychological, and metabolic consequences [25]. Sleep quality is influenced by various factors, including diet, environment, physical activity, and genetics [26]. In this study, sleep was disturbed in 70.6% of overweight/obese high school students. These disturbances could be attributed to sedentary hobbies such as watching television, using social media, and playing video games. These behaviors increase the consumption of unhealthy foods and lead to a reduction in energy expenditure. The consumption of energy drinks, with high levels

of caffeine reported by participants could indicate sleep disorders/disturbances. A meta-analysis by St-Onge et al. [27], found an association between sleep disorders and the consumption of energy drinks and the onset and progression of cardiovascular diseases, metabolic diseases, broncho-respiratory diseases, cancers, asthma, and depression.

Addictive behavior is a public health problem at all stages of life, particularly among adolescents. Tobacco and alcohol are important risk factors for non-communicable diseases [28]. These two major risk factors for non-communicable diseases raise concerns about the health and well-being of high school students in the short and long term. In this study, the prevalence of current smoking among overweight/obese high school students was 8.4%. In addition, smoking in the family environment was found in 35.9% of overweight high school students. The coexistence of overweight/obesity, active smoking and smoking within the family could pose a threat to the health of high school students [29]. This is why it would be important to integrate education items of certain risk factors for non-communicable diseases, such as smoking, into awareness programs on overweight/obesity in schools.

In this study, 82.5% of overweight/obese high school students had experienced stigma. Weight stigma is a phenomenon of devaluation experienced by excess adiposity individuals, both in society, within the family and at school [8]. It is the fourth most common form of stigma, after discrimination based on race, gender, and age [30]. Overweight or obese individuals also encounter cybernetic discrimination through social media. This type of discrimination can cause overweight or obese adolescents to experience depression, low self-esteem, and social isolation, potentially leading to increased food intake and snacking [31]. Moreover, 67.0% of them were ashamed of their current body size/image. This situation could also make it difficult to manage overweight or obesity since most of these people are ashamed to engage in physical activity due to the way peer groups or society view their body weight. In addition, the risk of mortality is higher among people who have been stigmatized [31].
Obesity is a risk factor associated with metabolic diseases (type 2 diabetes) and cardiovascular

diseases (high blood pressure) [8]. Apart from metabolic and cardiovascular complications, obesity is also associated with respiratory complications such as asthma [32]. Type 2 diabetes accounts for over 90% of diabetes cases [33]. In this study, diabetes was found in 58.9% of the families of overweight/obese high school students. In a previous study conducted by Barry et al. [20], in Guinea, the prevalence of a family history of diabetes was lower (41%) compared to the results obtained in this study. This disparity could be explained by the fact that the study by Barry et al. [20] was carried out in a peri-urban environment, unlike this study, which was carried out in a large city, with a larger sample. Genetic, behavioral, and environmental factors could explain this pattern between overweight/obesity and a family history of diabetes. Genetic factors are important in predisposing to overweight/obesity and diabetes [34]. Parents' eating and lifestyle habits may also influence those of their children. Environmental influences occur throughout development, beginning at conception, continuing through the growth period, and continuing into adulthood [35]. Including the home environment in the design of programs to combat overweight/obesity in children and adolescents could benefit both in the short and long term period [36].

As limitations, this study did not include the assessment of the quantity (portions) of food consumed. Information regarding parental overweight or obesity was also not collected. The descriptive design limited our study, especially in determining causation and control over variables, as we reported what we found only. Therefore, extensive longitudinal analytic studies involving all schools in Mali, and also including parental overweight/obesity and food portion details, are recommended to mitigate these limitations.

CONCLUSION

This study showed that overweight/obesity was higher among girls and private high school students. Several unhealthy behaviors, such as snacking, energy drink consumption, eating in front of screens, and physical inactivity outside of school, were observed among overweight/obese high school students. To reduce overweight among high school students, it is recommended that parents adopt good eating habits at home and

integrate nutritional education into their children's education. High school students should also limit their consumption of sugary drinks and fast foods while reducing their time spent watching television, video games and surfing the Internet. It is essential that the Ministries of Health and National Education promote good dietary practices and encourage the daily practice of physical and sporting activities in schools. Since there are significant links between overweight/obesity and metabolic and cardiovascular complications in adulthood, prevention during adolescence represents an important window of opportunity for public health officials.

REFERENCES

[1] J. Correia and A. Golay, "Un regard sur l'obésité en Afrique," Médecine Mal. Métaboliques, vol. 10, no. 2, pp. 182–185, 2016, doi: 10.1016/S1957-2557(16)30047-5.

[2] O. Barata Cavalcanti et al., "world Obesity Atlas 2022," 2022. [Online]. Available: www.worldobesity.org#worldobesityatlas

[3] T. Nguyen and D. C. W. Lau, "The Obesity Epidemic and Its Impact on Hypertension," Canadian Journal of Cardiology, vol. 28, no. 3. Elsevier, pp. 326–333, May 01, 2012. doi: 10.1016/j.cjca.2012.01.001.

[4] Z. Pataky and A. Golay, "Comprendre l'obésité en Afrique," Rev Med Brux, vol. 10, no. 1, pp. 712–716, 2014.

[5] S. Bloem and S. de Pee, "Developing approaches to achieve adequate nutrition among urban populations requires an understanding of urban development," Global Food Security, vol. 12, no. February. Elsevier, pp. 80–88, 2017. doi: 10.1016/j.gfs.2016.09.001.

[6] K. L. Dehne and G. Riedner, "Adolescence - A dynamic concept," Reprod. Health Matters, vol. 9, no. 17, pp. 11–15, 2001, doi: 10.1016/S0968-8080(01)90003-5.

[7] A. de Luca, "Besoins nutritionnels de l'adolescent," J. Pediatr. Pueric., vol. 32, no. 4, pp. 171–180, 2019, doi: 10.1016/j.jpp.2019.06.001.

[8] H. Jebeile, A. S. Kelly, G. O'Malley, and L. A. Baur, "Obesity in children and adolescents: epidemiology, causes, assessment, and management," Lancet Diabetes Endocrinol., vol. 10, no. 5, pp. 697–700, 2022, doi: 10.1016/j.athoracsur.2020.04.003.

[9] L. D. Delfino, W. R. Tebar, D. A. S. Silva, F. C. S. Gil, J. Mota, and D. G. D. Christofaro, "Food advertisements on television and eating habits in adolescents: A school-based study," Rev. Saude Publica, vol. 54, pp. 1–8, 2020, doi: 10.11606/S1518-8787.2020054001558.

[10] B. A. DIALLO, B. DIARRA, M. TOURE, D. A. CISSE, and B. DOUMBIA, "Etalement urbain à Bamako: facteurs explicatifs et implications," Afrique Sci., vol. 17, no. 6, pp. 58–75, 2020.

[11] D. Zitouni and B. C. Guinhouya, "Body mass index and childhood obesity classification systems : A comparison of the French , International Obesity Task Force (IOTF) and World Health Organization (WHO) references," Rev. Epidemiol. Sante Publique, no. 63, pp. 173–182, 2015, doi: 10.1016/j.respe.2014.11.003.

[12] S. Regaieg et al., "Obesity, physical activity and sedentary time among school adolescents aged 15 to 18 years in the city of Sfax (Tunisia)," Pan Afr. Med. J., vol. 22, p. 370, 2015, doi: 10.11604/pamj.2015.22.370.6121.

[13] A. D. Marsh et al., "Priority Indicators for Adolescent Health Measurement – Recommendations From the Global Action for Measurement of Adolescent Health (GAMA) Advisory Group," J. Adolesc. Heal., vol. 71, no. 4, pp. 455–465, 2022, doi: 10.1016/j.jadohealth.2022.04.015.

[14] S. A. Mwaikambo, G. H. Leyna, J. Killewo, A. Simba, and T. Puoane, "Why are primary school children overweight and obese? A cross sectional study undertaken in Kinondoni district, Dar-es-salaam," BMC Public Health, vol. 15, no. 1, pp. 1–10, 2015, doi: 10.1186/s12889-015-2598-0.

[15] V. G. Williamson, A. Dilip, J. R. Dillard, J. Morgan-Daniel, A. M. Lee, and M. I. Cardel, "The influence of socioeconomic status on snacking and weight among adolescents: A scoping review," Nutrients, vol. 12, no. 1, pp. 1–18, 2020, doi: 10.3390/nu12010167.

[16] J. R. Mabiala-Babela, J. Sabaye Alima, H. G. Monabeka, A. Mbika Cardorelle, J. L. Nkoua, and G. Moyen, "Profil épidémiologique et clinique de l'obésité de l'enfant à Brazzaville (Congo)," Cah. Nutr. Diet., vol. 46, no. 5, pp. 259–262, 2011, doi: 10.1016/j.cnd.2011.09.002.

[17] A. Ubesie, C. Okoli, S. Uwaezuoke, and A. Ikefuna, "Affluence and adolescent obesity in a city in south-east Nigerian: A cross-sectional survey," Ann. Trop. Med. Public Heal., vol. 9, no. 4, pp. 251–254, 2016, doi: 10.4103/1755-6783.184791.

[18] C. M. Pound and B. Blair, "Les boissons pour sportifs et les boissons énergisantes chez les enfants et les adolescents," Paediatr. Child Heal., vol. 22, no. 7, pp. 411–415, 2017, doi: 10.1093/pch/pxx167.

[19] R. McKetin, A. Coen, and S. Kaye, "A comprehensive review of the effects of mixing caffeinated energy drinks with alcohol," Drug Alcohol Depend., vol. 151, pp. 15–30, 2015, doi: 10.1016/j.drugalcdep.2015.01.047.

[20] I. K. BARRY, M. Kouyate, I. CONDE, E. CAMARA, and M. E. HYJAZI, "Prévalence de la surcharge pondérale (surpoids et obésité) en milieu scolaire urbain à Kamsar République de Guinée," Nutr. Santé, vol. 09, no. 1, pp. 9–17, 2020, doi: 10.30952/ns.9.1.2.

[21] E. K. Dunford and B. M. Popkin, "37 year snacking trends for US children 1977–2014," Pediatr. Obes., vol.

13, no. 4, pp. 247–255, 2018, doi: 10.1111/ijpo.12220.

[22] N. M. Almoraie, R. Saqaan, R. Alharthi, A. Alamoudi, L. Badh, and I. M. Shatwan, "Snacking patterns throughout the life span: potential implications on health," Nutr. Res., vol. 91, pp. 81–94, 2021, doi: 10.1016/j.nutres.2021.05.001.

[23] R. Guthold, G. A. Stevens, L. M. Riley, and F. C. Bull, "Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants," Lancet Child Adolesc. Heal., vol. 4, no. 1, pp. 23–35, 2020, doi: 10.1016/S2352-4642(19)30323-2.

[24] M. Duclos, "Epidemiology and morbi-mortality effects of physical activity and sedentariness in the general population," Rev. du Rhum. Monogr., vol. 88, no. 3, pp. 177–182, 2021, doi: 10.1016/j.monrhu.2020.11.008.

[25] A. Brion, "Les conséquences du manque de sommeil à l'adolescence," Med. du Sommeil, vol. 8, no. 4, pp. 145–151, 2011, doi: 10.1016/j.msom.2011.09.002.

[26] M. Sejbuk, I. Mirończuk-Chodakowska, and A. M. Witkowska, "Sleep Quality: A Narrative Review on Nutrition, Stimulants, and Physical Activity as Important Factors," Nutrients, vol. 14, no. 9, 2022, doi: 10.3390/nu14091912.

[27] M. P. St-Onge, A. Mikic, and C. E. Pietrolungo, "Effects of diet on sleep quality," Adv. Nutr., vol. 7, no. 5, pp. 938–949, 2016, doi: 10.3945/an.116.012336.

[28] A. Makoutode, J. Saizounou, Y. Glele Ahanhanzo, C. J. Sossa, and V. Agueh, "Prévalence et facteurs associés à la surcharge pondérale chez les adolescents dans une ville secondaire au Bénin," Int. J. Biol. Chem. Sci., vol. 11, no. 2, p. 798, 2017, doi: 10.4314/ijbcs.v11i2.21.

[29] A. Lee, S. Y. Lee, and K. S. Lee, "The Use of Heated Tobacco Products is Associated with Asthma, Allergic Rhinitis, and Atopic Dermatitis in Korean Adolescents," Sci. Rep., vol. 9, no. 1, pp. 1–8, 2019, doi: 10.1038/s41598-019-54102-4.

[30] M. Vadiveloo and J. Mattei, "Perceived Weight Discrimination and 10-Year Risk of Allostatic Load Among US Adults," Ann. Behav. Med., vol. 51, no. 1, pp. 94–104, 2017, doi: 10.1007/s12160-016-9831-7.

[31] F. Rubino et al., "Joint international consensus statement for ending stigma of obesity," Nat. Med., vol. 26, no. 4, pp. 485–497, 2020, doi: 10.1038/s41591-020-0803-x.

[32] N. Boulekhiout-Bechikh, O. Drali, F. Khelfat, M. Moubri, H. Berrah, and Z. Arrada, "Contrôle de l'asthme chez 92 adolescents en surpoids," Rev. Fr. Allergol., vol. 60, no. 4, p. 365, 2020, doi: 10.1016/j.reval.2020.02.178.

[33] N. Lascar, J. Brown, H. Pattison, A. H. Barnett, C. J. Bailey, and S. Bellary, "Type 2 diabetes in adolescents and young adults," Lancet Diabetes Endocrinol., vol. 6, no. 1, pp. 69–80, 2018, doi: 10.1016/S2213-8587(17)30186-9.

[34] E. M. Drummond and E. R. Gibney, "Epigenetic regulation in obesity," Curr Opin Clin Nutr Metab Care, vol. 16, no. 4, pp. 392–397, 2013, doi: 10.1097/MCO.0b013e3283620f45.

[35] S. Nicolaidis, "Environment and obesity," Metabolism., vol. 100, pp. 1–5, 2019, doi: 10.1016/j.metabol.2019.07.006.

[36] M. Henderson and D. Ph, "Canadian Journal of Diabetes," Can. J. Diabetes, vol. 35, no. 2, p. 84, 2011, doi: 10.1016/s1499-2671(11)52001-5.