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Anthropometric indices and cardiometabolic risk factors in a Ghanaian adolescent population

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Abstract

Objectives: Adolescent overweight and obesity is a public health concern globally, especially in lower- and middle-income countries where there is an additional burden of undernutrition. The prevalence of adolescent overweight/2obesity has increased markedly over the past three decades. The transition in dietary habits coupled with reduced physical activity has been blamed for the increasing trend. Overweight/obesity in adolescence is complicated by cardiometabolic, respiratory, musculoskeletal and psychosocial disorders. Additionally, adolescent obesity is a predictor of future development of type 2 diabetes, cardiovascular diseases and metabolic disorders. The burden of cardiometabolic risk factors associated with adolescent overweight/obesity in Ghana is lacking, the project, therefore, was undertaken to add to the existing knowledge.
Methods: The study was undertaken in adolescent students of a tertiary institution in Ghana. Two hundred and one students consented to participate in the study. Questionnaires on sociodemographic characteristics, dietary and substance abuse habits were self-administered. Blood pressure, height, weight and waist circumference measures were performed and venous blood drawn for the determination of fasting serum total/LDL/HDL cholesterol and triglycerides. Body mass indices were determined as the weight per square of their heights.
Results: The prevalence of obesity was determined to be 15.81% generally, 27.71% in the females and 7.08% in the males. Diastolic blood pressure was the only cardiometabolic risk factor significantly associated with obesity in our study.
Conclusion: Overweight/obesity is common in Ghanaian adolescents, with the prevalence highest in the female population.

Keywords: adolescent; cardiometabolic risk factors; Ghana; malnutrition double burden; obesity; overweight.

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Introduction

Adolescence is the period between childhood and adulthood, it is characterised by marked physiological and psychosocial changes leading to adulthood [1]. The expanded definition now considers age range from 10–24 years of age as compared with the previous definition of 10–19 years [2]. The health care burden in the adolescent population has shifted dramatically over the decades. For example, the nutritional transition over the decades has resulted in a dramatic increase in adolescent overweight and obesity globally [1]. Adolescent overweight and obesity defined by the WHO respectively as one and two standard deviations above the median BMI-for-age and for -sex respectively, has over the decades become a serious public health challenge globally, especially in low- and middle-income countries (LMIC) [3]. The incidence of adolescent obesity has increased significantly worldwide over the past three decades [1]. As at 2016, an estimated 340 million children and adolescent aged between 5 and 19 years were either overweight or obese, with the global prevalence currently estimated at 18%, compared with 4% in the 1970s [4]. The increase in prevalence over the decades has been more pronounced in most LMIC, where there is an additional challenge of undernutrition, in what has been termed the “double burden of malnutrition” [5].

The imbalance between energy intake and expenditure underlie the evolution of obesity in adolescence with a complex interaction between genetic and environmental risk factors implicated [6]. Environmental risk factors associated with the development of obesity in adolescence include the increased intake of processed foods high in calories and low in nutritional elements, increasing sedentary lifestyle coupled with low levels of physical activities and psychosocial disorders resulting in eating disorders [7–9]. The easy accessibility to highly processed foods in most LMICs largely explains the recent explosion in the incidence of adolescent overweight and obesity, especially in higher socio-economic status [10]. Although the genetic aetiology of overweight and obesity are polygenic, a genome association studies have implicated *FTO* gene, with increased expression in the hypothalamus and some variants the *FTO* implicated in eating disorders such as emotional overeating and binge eating [10, 11].

Overweight and obesity in adolescence is associated with several short and long term complications [12, 13]. These complications include; pulmonary disorders such as asthma and obstructive sleep apnoea [14, 15], cardiometabolic and cardiovascular disorders such as type 2 diabetes (T2DM), dyslipidaemia, insulin resistance, hypertension, ventricular hypertrophy, etc. [16–19], endocrine disorders like polycystic ovarian syndrome, androgenism [20, 21]. Additional complications include gastrointestinal disorders like fatty liver, gut microbiota dysbiosis [22, 23], musculoskeletal disorders including impaired mobility, lower extremity joint pains, etc. [24, 25]. and psychosocial correlates including low self esteem, anxiety, depression etc [26]. In the long term, there is an increased risk of developing conditions such as T2DM, cardiovascular conditions like strokes and myocardial infarction, cardiac metabolic dysfunction and cancers [27, 28]. Early diagnosis of adolescent overweight and obesity and the subsequent intervention is imperative, to prevent the progression of these potential comorbidities into adulthood [27]. The Expert Committee on the Assessment, Prevention, and Treatment of Child and Adolescent Overweight and Obesity recommends the stepwise approaches to the management of overweight and obesity in adolescence depending on the severity [29].

In Ghana, obesity has generally been viewed as a public health challenge [30], with some studies targeted at children and adolescents [31–34]. However, cardiometabolic risk factors associated with adolescent overweight and obesity in Ghana to our knowledge has been sparingly researched. We, therefore, undertook the study to determine the prevalence and predictors of overweight/obesity, and additionally, to determine the burden of some cardiometabolic risk factors associated with obesity and metabolic syndrome among adolescents in Ghana.

Materials and methods

Study area, population and design

The study was undertaken at the University of Cape Coast, Cape Coast in the Central Region of Ghana. The university was established in 1973 and had a student population of about 75,000 with a total of 24723 admissions in the 2016/17 academic year [35]. First year students, 20 years of age or below reporting to the University of Cape Coast Hospital for a mandatory entry medical examination in August and September 2018 were eligible to be included in the study. Participants with an extant history of T2DM or cardiometabolic disorders were excluded from the study.

The University of Cape Coast Institutional Review Board granted the approval for the study (UCCIRB/CHAS/2015/19). Additionally, permission was sought from the University of Cape Coast Hospital management before the commencement of the study.

Study design

An observational cross-sectional study design was utilised to answer the research questions. Participants fulfilling the eligibility criteria were recruited into the study once an informed written consent had been obtained. A total of 201 students consented to be part of the study.

Subsequently, questionnaires on demographics, dietary practices, substance abuse and physical activities were allocated to the students to be self- administered.

Measurements

All participants underwent complete physical examination, including blood pressure, height, weight and waist circumference measurements. The standing height, weight and waist circumference measurements were undertaken according to the Centers for Disease Control guidelines [36]. Weights of the subjects were measured to the nearest 0.1 kg using the Omron Body Composition Monitor BF511 (Omron Healthcare Inc., USA). The scale was placed on a hard surface and the participants were asked to empty pockets of any heavy objects like mobile phones, bunch of keys, and stood in the centre of the platform with their weight distributed evenly to both feet. Heights of subjects were measured to the nearest 0.5 cm using a wall-mounted stadiometer. Participants were asked to remove their sandals and made to stand upright with their back to the height rule. The waist circumference of the subjects was measured at a level midway between the lower rib margin and iliac crest with the tape all around the body in a horizontal position. Participants were made to stand with their feet fairly close together and their weight equally distributed to each leg.

Percentage body fat and visceral fat were measured with Omron Body Composition Monitor BF511 (Omron Healthcare Inc., USA).

The CDC online body mass index (BMI) calculator for Children and Teens was used to assess the percentile BMI of the student below 20 years according to their height, weight, sex and age [37]. Conventional BMI calculation for adults, that is weight over height squared was used to calculate BMI for students who were 20 years of age. BMI for students who were 20 years of age was calculated as weight in kilograms divided by height in squared meters. Blood pressures of subjects were determined using the Omron IntelliSense BP742 Blood Pressure Monitor (Omron Healthcare Inc., USA). The readings were taken after allowing participants to rest for at least 5 min. Three readings were taken and the average of the last two readings recorded as the student's blood pressure.

About 2 mL of venous blood samples were obtained from the subjects after overnight fast (8–14 h) for the determination of total cholesterol, high density lipoprotein cholesterol (HDL), and triglycerides using the Mindray BS-120 Chemistry Analyzer (Mindray Bio-Medical Electronics, China). Low density lipoprotein cholesterol (LDL) was estimated using the Friedewald equation:

$$LDL - C[LDL - C = TC - HDL - C - (TG/5)]$$ [38]

Statistical analyses

Data from the study were entered into the web-based Epicollect5 (http://five.epicollect.net) [39]. Data was only accessible to the study group members. The data were exported to Excel (Microsoft Inc., USA) in an excel format. Data analyses for proportions were undertaken using the OpenEpi [40], association analyses were performed in GraphPad Prism version 7.0a (GraphPad Software Inc., USA) and the regression analyses performed in R software [41]. Continuous parametric variables were presented as mean and 95% confidence interval. Categorical variables were presented as proportions and percentages and compared by Pearson's chi-square test or Fisher's exact test.

Results

A total of 201 adolescent first year students consented to be part of the study, however, due to incompleteness of data for 5, 196 of the student data were used for further analyses. The age of the students ranged from 16 to 20 years with a mean age 18.43 (SD=±0.78) years ranging between 16 and 20 years. Males made up 57.65% (113) with an average age of 18.27 (±0.87) years and the females had an average of 18.56 (±0.69) the majority of the students, that is, 85.72% were either 18 or 19 years old, with Ghanaian students making up the majority of participants, that is 193 (98.47%), with the remaining being two Togolese and an Ivorian student. Figure 1 shows the locations of the student's current town of residence, with the majority of the respondents residing in the southwestern part of Ghana.

The prevalence of overweight/obesity was 15.81% (95% CI=11.37, 21.43), with the prevalence in the female population being 27.71% (95% CI=19.18, 38.16), whereas it was 7.08% (95% CI=3.63, 13.35) in the male population among the participants. The prevalence of obesity, overweight and underweight were 4.59 (95% CI=2.43, 8.50), 11.22 (95% CI=7.53, 16.41) and 11.73% (95% CI=7.95, 16.99) among the sample population. Children of mothers with a

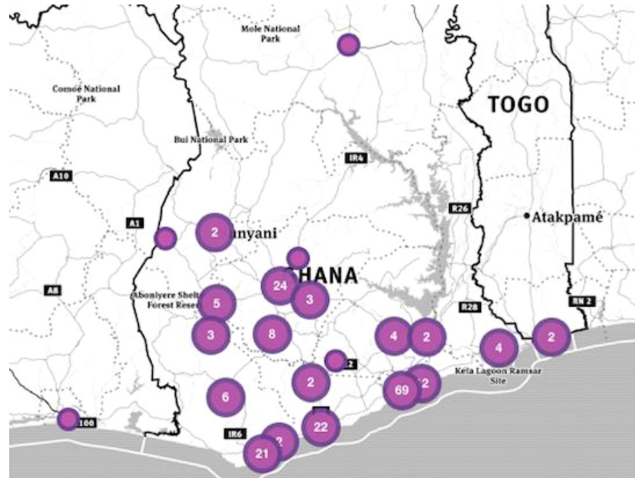

Figure 1: A map of Ghana showing the residential locations of the participants. (Map was rendered in Epicollect 5).

secondary school education or higher had an overweight/obesity prevalence of 13.48% (95% CI=7.89, 22.1) compared with 17.76% (95% CI=11.67, 26.08) in participants with mother's with an educational level less than secondary school education. The overweight/obese prevalence among participants whose father's highest educational level was up to secondary school or higher and below secondary school level were 14.4 (95% CI=) and 18.31% (95% CI=11.03, 28.85), respectively.

Table 1 shows the prevalence of overweight/obesity among various categories of the demographic characteristics and socioeconomic indicators within the general sample population. Test of association was performed using the Pearson's χ^2 Test of association or Fisher's exact test to determine the statistical significance of the association between the demographic and socioeconomic categories and BMI category. There was a statistically significant association between the sex and BMI category with an Odds ratio of 5.03 (95% CI=2.13, 11.32). However, there was no statistically significant association between the BMI category and the rest of the demographic parameters.

Table 2 shows the results of a test of association between the BMI category and nutritional and substance abuse characteristics using Pearson's χ^2 test of association or Fisher's exact test. There was a statistically significant association found between the periodicity of fruit intake and BMI category, with an Odds ratio of 2.77 (95% CI=1.26, 6.12). The rest showed no statistically significant association. Regarding substance abuse, only 2 (1.05%) of the students had a prior history of smoking, although both had

Table 1: Test of association between socio-demographic data and BMI category.

Category (n=196)	Sub-category	Normal/Underweight n (%)	Overweight/obese n (%)	p-Value
Age	16	4 (2.04)	0 (0.00)	0.516
	17	14 (7.14)	2 (1.02)	
	18	59 (30.10)	16(8.16)	
	19	81 (41.33)	12 (6.12)	
	20	7 (3.57)	1 (0.51)	
Sex*	Male	105 (53.57)	8 (4.08)	0.000
	Female	60 (30.61)	23 (11.73)	
Nationality	Ghanaian	164 (83.67)	29 (14.80)	0.066
	Foreigner	1 (0.51)	2 (1.02)	
Ethnicity	Akan	125 (63.78)	24 (12.24)	0.994
	Ewe	16 (8.16)	3 (1.53)	
	Ga-Adangme	13 (6.63)	2 (1.02)	
	Others	11 (5.61)	2 (1.02)	
Region of residency	Greater Accra	52 (26.53)	14 (7.14)	0.441
	Ashanti	34 (17.35)	4 (2.04)	
	Central	32 (16.33)	3 (1.53)	
	Western	28 (14.29)	6 (3.06)	
	Others	19 (9.63)	4 (2.04)	
Mother's highest educational level	<Secondary school	88 (44.90)	19 (9.69)	0.556
	≥Secondary school	77 (39.29)	12 (6.12)	
Father's highest educational level	<Secondary school	58 (29.59)	13 (6.63)	0.542
	≥Secondary school	107 (54.59)	18 (9.18)	

Pearson's χ^2 test of association or Fisher's exact test was used to test for association between the BMI category and socio-demographic characteristics. p-Value was considered significant at 0.05%. *means association is significant.

Table 2: Test of association between nutritional and substance abuse indices and BMI category.

Category (n=196)	Sub-category	Normal/Underweight (n=165) n (%)	Overweight/Obese (n=31) n (%)	p-Value
Ice cream intake	≤Once a week	140 (71.43)	29 (14.80)	0.263
	>Once a week	25 (12.76)	2 (1.02)	
Fast food intake	≤Once a week	122 (62.24)	21 (10.71)	0.511
	>Once a week	43 (21.94)	10 (5.10)	
Sweetened soft drink intake	≤Once a week	92 (46.94)	18 (9.18)	0.846
	>Once a week	73 (37.24)	13 (6.63)	
Fruit intake*	≤Once a week	105 (53.57)	12 (6.12)	0.016
	>Once a week	60 (30.61)	19 (9.69)	
Vegetable intake	≤Once a week	69(35.20)	9 (4.59)	0.231
	>Once a week	96 (48.98)	22 (11.22)	
Current smoking habit	No	163 (83.18)	31 (15.82)	1.000
	Prior smoking history	2 (1.02)	0 (0.00)	
Current drinking habit	No	157 (80.10)	29 (14.80)	0.489
	Prior drinking history	4 (2.04)	1 (0.51)	
	Yes	4 (2.04)	1 (0.51)	

Pearson's χ^2 or Fisher's exact test was used to test for association between BMI-type and demographic characteristics. p-Value was considered significant at 0.05%. *means association is significant.

quit as at the study period. However, about 5.10% of the students had either taken alcohol previously (2.55%) or were currently taking alcohol (2.55%).

Table 3 shows the association between categories of cardiometabolic indices and BMI category. The blood pressures were categorised into normal and elevated blood pressure/hypertension according to the American Academy of Pediatricians (AAP) guidelines for the screening of hypertension in adolescents 13 years or above [42]. The cholesterol and triglyceride levels were categorised

Table 3: Test of association between cardio-metabolic indices and BMI category.

Category (n=196)	Sub-category	Normal/Underweight (n=165) n (%)	Overweight/Obese (n=31) n (%)	p-Value
Systolic BP	Normal	81 (41.33)	13 (6.63)	0.56
	Elevated BP/Hypertension	84 (42,86)	18 (9.18)	
Diastolic BP*	Normal	159 (81.12)	26 (13.27)	0.017
	Elevated BP/Hypertension	6 (3.06)	5(2.55)	
Total cholesterol	Acceptable	118 (60.20)	21 (10.71)	0.67
	Borderline high/High	47 (23.98)	10 (5.10)	
LDL cholesterol	Acceptable	151 (77.04)	25 (12.76)	0.067
	Borderline high/High	14 (7.14)	6 (3.06)	
HDL cholesterol	Acceptable	127 (64.80)	24 (12.24)	0.96
	Borderline low/Low	38 (19.39)	7 (3.57)	
Triglycerides	Normal	137 (69.90)	28 (14.29)	0.30
	Borderline high	28 (16.97)	3 (1.53)	

Pearson's χ^2 was utilised to test the association between cardio-metabolic indices and BMI category. p-Value was considered significant at 0.05%. *means association is significant.

Table 4: Multivariate regression to determine the socio-demographic and dietary predictors of overweight and obesity.

Variable	Crude OR (CI 95%)	Adjusted OR (CI 95%)
Age	1.21 (1.0, 1.47)	1.20 (0.97, 1.46)
Sex	0.99 (0.73, 1.34)	1.32 (0.94, 1.84)
Nationality	1.38 (0.68, 2.82)	1.97 (0.92, 4.23)
Ethnicity	0.97 (0.86, 1.09)	0.95 (0.85, 1.08)
Region of residence	1.03 (0.97, 1.09)	1.03 (0.97, 1.09)
Mother's highest educational level	0.97 (0.86, 1.09)	1.00 (0.87, 1.16)
Father's highest educational level	0.94 (0.84, 1.05)	0.91 (0.80, 1.04)
Smoking status	0.41 (0.09, 1.86)	0.37 (0.08, 1.65)
Alcohol drinking status	1.82 (0.94, 3.55)	1.81 (0.92, 3.56)
Ice cream intake	0.85 (0.76, 0.94)*	0.83 (0.73, 0.94)*
Fast food intake	0.94 (0.85, 1.04)	0.96 (0.86, 1.09)
Sweetened beverages	0.96 (0.87, 1.05)	1.03 (0.92, 1.15)
Fruit intake	0.99 (0.90, 1.09)	1.07 (0.95, 1.20)
Vegetable intake	0.94 (0.85, 1.03)	0.93 (0.83, 1.04)

Crude and adjusted Odds ratio was calculated using the binomial and multinomial logistics regression model. Results were reported as the odds ratio and 95% confidence interval (CI 95%). *means significant predictor. OR=odds ratio.

according to the AAP guidelines (from the National Cholesterol Education Program Expert Panel on Cholesterol Levels in Children recommendations). Total cholesterol, LDL cholesterol and triglycerides were categorised into acceptable and borderline high/high, HDL cholesterol was categorised into acceptable and borderline low/low. There was a significant association between the BMI category and diastolic blood pressure with an Odds ratio of 5.10 (95% CI=1.589, 19.28).

A multiple logistics regression analyses of some demographic, nutritional and substance abuse characteristics were utilised to determine the likely predictors of overweight/obesity and the results are shown in Table 4. Ice cream intake was found to predict BMI category with a crude and an adjusted Odds ratios of 1.17 (CI 95%=1.06, 1.32) and 1.20 (CI 95%=1.06, 1.37), respectively.

In addition, we applied the International Diabetes Federation (IDF) criteria for diagnosing metabolic syndrome in adolescents, a measure of pre-diabetes [21] to determine the prevalence of metabolic syndrome. The prevalence of central adiposity, defined as a waist circumference greater than 94 cm in males and 80 cm in females 16 years of age or above by the IDF [43] was determined to be 6.63%. The prevalence of metabolic syndrome, that is the presence of central adiposity with two additional IDF criteria was determined to be 2.04% (without fasting blood sugar criterion).

The systolic and diastolic blood pressure categories were defined according to the AAP paediatric hypertension guidelines [44]. The prevalence of elevated blood pressure/hypertension per the systolic blood pressure (>120 mmHg) was 52.04% generally and 58.06% among the overweight/obese. The prevalence of elevated blood pressure/hypertension per the diastolic blood pressure (>80 mmHg) was 5.61% generally and 16.13% in the overweight/obese population.

The categorisation of serum lipids in the participants was performed using the American Academy of Pediatrics guidelines adapted from the National Cholesterol Education Program Expert Panel on Cholesterol Levels in Children [45]. The following categories were used: total cholesterol (acceptable2.33mmol/L, borderline high/high≥2.33 mmol/L), LDL cholesterol (acceptable<2.85 mmol/L, borderline high/high≥2.85 mmol/L), HDL cholesterol (acceptable>1.17 mmol/L, borderline low/low≤1.17 mmol/L) and triglycerides (acceptable<1.02 mmol/L, borderline high/high≥1.02 mmol/L). Utilising these definitions, we determined the prevalence of borderline high/high total cholesterol, LDL cholesterol and triglyceride to be 29.08%, 10.20 and 15.81%, respectively, in the sampled population, additionally, the prevalence within the overweight/obese subpopulations were 32.26, 19.35 and 9.68% respectively. The prevalence of acceptable HDL cholesterol in the general sampled population was 22.96%, with prevalence in the overweight/obese subpopulation being 22.58%. Table 3 shows the test of association between the overweight/obese and the categories of serum cholesterol, triglycerides and blood pressures.

The primary data supporting the result presented here has been deposited in Mendeley Data Repository (**DOI:** 10.17632/vs6xspx446.2).

Discussion

By 2025, it is projected that the prevalence of obesity in Ghana would have reached 23.6 and 7.9% in women and men, respectively, with diabetes affecting 9.1% of women and 8.4% of men potentially [46]. It is thus imperative that policy measures aimed at identifying and managing adolescent overweight/obesity are implemented expeditiously to forestall a future public health catastrophe. This work was undertaken to determine the burden of overweight/obesity among an adolescent population and to quantify the inherent cardio-metabolic risks. The prevalence of overweight/obesity in our study was 15.81%, which was lower than the global prevalence of about 18%. The prevalence was higher in females (28%) than in males (7%), however, this disparity could have resulted from inherent sampling bias in the study. Biritwum et al. [47] in 2005 reported the prevalence of overweight and obesity of 10.5 and 1.2% in 18 year olds, 15.1 and 0% in 19 year olds and 6.9 and 0% in 20 year olds. In 2011, a study performed in Ugandan and Ghanaian adolescent aged 13–15 years of age reported a prevalence of 10.4% in girls and 3.2% in boys [34]. These studies compared with ours reveal that there is an increasing trend in the prevalence of adolescent overweight and obesity in Ghana. The increasing trend of adolescent overweight/obesity in Ghana compares with similar trends in most LMIC, where nutritional transition fuelled by aggressive marketing of energy-dense foods and beverages has resulted in marked increase in prevalence over the decades [5, 10].

Almost one in three of the female participants were overweight/obese in our study compared with less than one in 10 for the males, which is a similar trend to previously reported studies in adolescent and adult populations in Ghana [31, 33, 34, 47–49]. The preponderance of females with overweight/obesity in our study is similar to what has been reported from most LMIC and developed economies [50]. Some reasons adduced to explain this phenomenon include the propensity for male adolescents to engage in more rigorous physical activities and social constraints of overweight and obese females appearing more desirable to the males [9, 49].

In most developed economies, overweight/obesity tend to be associated with adolescents from low socioeconomic background, the converse is true in most LMICs. Adolescents from high socioeconomic backgrounds are more exposed to and can afford energy-dense fast foods, processed foods and beverages as opposed to those from low socioeconomic backgrounds who still depend on healthy traditional foods [1, 33, 50]. However, the results from our study revealed a higher prevalence of overweight/obesity in participants from lower socio-economic status albeit not statistically significant.

Coupled with the increasing trend in overweight/obesity prevalence, is the persistence of underweight in the population in Ghana. Our study reports an underweight prevalence of 23%, which was almost similar to the 25% reported by Mayanga et al. [33]. Yang et al. [51], however, reported a prevalence of 16.1% in the adolescent African population in 2018. Globally, the prevalence has changed slightly from 9.2% in 1975 to 8.4% in 2016, and in Africa from 42 to 34% [52]. Thus, there is a decreasing trend in underweight prevalence generally, however, due to population growth over the period, the quantum of the underweight population would increase markedly. Therefore, policies aimed at tackling malnutrition in adolescences should encompass both the underweight and overweight/ obesity populations.

Association between poor dietary intake and the development of overweight and obesity in adolescence has been established [7]. Dietary habits of an individual are established and reinforced during adolescence and it is influenced by factors including personal proclivities and intrapersonal relationships (e.g. eating habit), socio-environmental interpersonal relationships (e.g. family, friends and peer influences), communal and physical environmental influences (e.g. easy accessibility to energy-dense foods at the community level) and macrosystem influences (e.g. media, advertisement, government policies [53, 54]. Our study did not show any significant association between the periodicity of consumption of energy-dense diets like sweetened beverages, ice cream and fast foods and an individual's BMI category. Surprisingly, our data revealed eating fruits at more than once a week was significantly associated with developing overweight/ obesity with odds of 2.77. The dietary history was elicited from the students from a monthly recall, therefore, the response may not have been quite accurate. The challenges from the monthly dietary recall could explain the unexpected results we saw in our study.

Overweight and obesity in adolescence are complicated contemporarily and the future by a myriad of cardiometabolic disorders including hypertension, T2DM, atherosclerosis, ischaemic heart diseases, strokes etc. [55]. Thus, screening for potential risk factors in the adolescent population is imperative, as a majority will maintain these risk factors into adulthood. To determine the cardiometabolic risk factors associated with adolescent overweight and obesity among the study population, we measured the following parameters, systolic and diastolic blood pressure, waist circumference and serum cholesterol and triglycerides. The current study revealed the prevalence of cardiometabolic risk factors were higher in the overweight/obesity participants compared with the general sampled population, except the serum triglyceride concentration where the reverse was the result. However, the test of association was statistically significant to the diastolic blood pressure category. A recent systematic review has reported a paucity of data on cardiometabolic risk factors among the adolescent overweight/obese population in sub-Sahara Africa [50]. Some studies in Ghana have reported pre-hypertension (elevated blood pressure) and hypertension prevalence of 28.3, 36.3 and 39.2% among some adolescent and youth populations [31, 56, 57], which were less than what we are reporting. The high prevalence we reported could have resulted from "white coat" effect [58], as our study was conducted in a clinic setting. A study in South Africa revealed a positive association between obesity and systolic blood pressure but a negative association to diastolic blood pressure, whereas our study revealed a positive association between elevated diastolic blood pressure/hypertension and overweight/obesity.

Conclusion

We have shown that overweight and obesity prevalence in adolescent Ghanaians have increased over the past decades with a significant preponderance in females. The double burden of malnutrition revealed in the current study poses a public health challenge in Ghana, with the potential future burden on a health care system already overwhelmed by infectious diseases. Cardiometabolic risk factors associated with overweight/obesity were prevalent, although, no significant associations with overweight/ obesity were noted except with diastolic blood pressure.

Increasing the power of the study will be recommended, in order to determine the true burden of obesity and associated risk factors within the adolescent population of Ghana.

Limitations

The initial aim of the study was to determine the metabolic syndrome burden in the adolescent population of Ghana, however, due to logistical constraints, we were unable to measure fasting blood glucose concentration. Additionally, we were unable to get accurate dietary information, because the questionnaires sought for monthly dietary recall. Physical activity routines were also not sought for in the questionnaire, thus, the contribution of physical activity to BMI category could not be estimated.

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Sirikyi, Sebastian Eliason, Oheneba C. K. Hagan and Paul Nsiah drafted the manuscript and critical review of the manuscript undertaken by Evans Ekenam, Frank N. Ghartey, Kingsley K. A. Pereko and Emmanuel Okai.

Competing interests: No funding organizations played a role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the report for publication.

Ethical statement: Approval for the study was granted by the University of Cape Coast Institutional Review Board (UCCIRB/CHAS/2015/19) and additionally permission was sought from the University of Cape Coast Hospital management. An informed written consent had been obtained.

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