Total Body Fat is Associated with Increased Risk for Pre-diabetes and Hypertension among Secondary School Adolescents in Morogoro Region, Tanzania

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Abstract

Aims: We aimed to determine the prevalence and determinants of type 2 diabetes mellitus and hypertension among adolescents in Morogoro region, Tanzania.

Methods: This was a cross-sectional study, which involved 384 adolescent students. Standard procedures were used to measure weight, height, body fat percentage, blood pressure and random blood glucose levels. Hyperglycemia was diagnosed using American Diabetes Association criteria and hypertension diagnosed using American Heart Association Guidelines for childhood hypertension. Dietary assessment was done using a validated dietary diversity questionnaire. Physical activities were assessed using a self-administered 7-day recall physical activity questionnaire for adolescents. Statistical analyses was done using IBM SPSS version 21. The Chi-square and logistic regression analysis were used to determine determinants for diabetes and hypertension.

Results: Prevalence of pre-diabetes was more than twice as much (7.3%) in the urban compared to the rural areas (3.1%). Determinants of pre-diabetes were overweight/obesity (OR 5.64; 95% CI 2.82–11.31), school type (OR 1.99; 95% CI 1.04–3.84) and elevated body fat (EBF) (OR 1.06; 95% CI 1.03 – 1.09). Likewise, prevalence of hypertension was much higher among urban adolescents (17.2%) compared to their peers (5.7%). Determinants of hypertension were location (OR 1.85; 95% CI 1.11 – 3.07), overweight/obese (OR 5.89; 95% CI 3.19 – 10.89), elevated body fat (EBF) (OR 1.14; 95% CI 1.09 – 1.19) and low physical activities (OR 1.58; 95% CI (1.35 – 3.48).

Conclusion: High prevalence of pre-diabetes and hypertension among adolescents is alarming. Total body fat and increased BMI are associated with increased risk for pre-diabetes and hypertension. Promotion of healthy lifestyle should start at a younger age to prevent development of diet related non-communicable diseases.

Keywords: Pre-diabetes; Hypertension; Adolescents; Prevalence; Determinants

Introduction

The prevalence of non-communicable diseases is increasing rapidly in the world; triggered by changes in lifestyle, dietary patterns, and increasing overweight and obesity at a younger age [1,2]. In the past, type 2 diabetes mellitus (T2DM) was considered as a disease of adults, however, in the last decade; a worldwide increase in prevalence of T2DM in both adults and children has been reported [3].Until 10 years ago, T2DM accounted for less than 3% of all cases of new-onset diabetes in adolescents, and at present it represents 8 to 45% of new cases and is commonly diagnosed between the ages of 12 and 16 years and in those with positive family history of T2DM [4].

Hypertension in adolescents has also increasingly become a public health problem of global concern in the last few decades [5]. The prevalence of hypertension in children and adolescents in developing countries has been established through systematic reviews to be between 1 and 5% [6, 7]. A cross-sectional study conducted among adolescents and youths (12-24 years of age) attending schools and college in Tanzania and Uganda determined the prevalence of high blood pressure (BP) and associated factors. The overall prevalence of high BP was 40% whereas the prevalence of pre hypertension was 29% and that of hypertension was 11% [8].

Obesity is a risk factor for T2DM, hyperlipidemia, renal disease, hypertension, other cardiovascular diseases, and certain cancers, all of which reduce life expectancy [9]. Worldwide, the prevalence of childhood overweight and obesity combined has risen by 47.1% between 1980 and 2013 [10]. World Health Organization (2015) reported that the global prevalence of childhood obesity has increased from 31 million to 42 million children, and increased in Africa alone from 4 to 10 million children during the period from 1990 to 2013 [11].

Longitudinal studies of obesity and chronic disease risk among adolescents and youth (10-24 years of age) suggest an increased risk of morbidity and premature mortality from coronary heart disease, stroke, hypertension, diabetes, and asthma among adults who were overweight or obese during adolescence [12]. Therefore, the onset of obesity and overweight during adolescence may persist to adulthood and cause greater health effects in the future, thus there is a need for routine assessment among secondary school adolescents so as to prevent further complications.

While the burden of diet related non-communicable diseases (NCDs) is increasing in developing countries, there has been little focus on adolescence, when the majority of behavioral risk factors for NCDs first emerge. Yet Target 3.4 of Sustainable Development Goal number 3, which covers diet related NCDs among other non-communicable diseases, makes no mention of young people, and it does not address the need to focus on prevention amongst this age group [13]. Indeed, young people are often neglected when it comes to policymaking about the health risks they face. This study, therefore, aimed at determining the prevalence and risk factors associated with T2DM and hypertension among secondary school adolescents in Morogoro region, Tanzania.

Methodology

Study areas

The study was conducted in Morogoro region in two districts, Morogoro municipality representing an urbanized population and Kilosa district representing rural area. Morogoro is one of the thirty-one main regions in Tanzania. It is made up of seven districts namely; Morogoro rural, Morogoro urban (municipality), Ulanga, Kilombero, Gairo, Mvomero and Kilosa. The 2012 Tanzania National Population Census reported that, the estimated total population of Morogoro region was 2,218,492. Rural and urban population constitutes different proportions where by rural areas population was 1,582,434 and urban population being 636,058. For the age group 10-19 years (adolescents) the population was 495, 654 [14].

Study design and sample size

A descriptive cross-sectional study design was used to conduct this research. The study included adolescent students both males and females with age ranging from 14 to 19 years [15], attending ordinary level secondary schools from private and government schools with the exclusion of boarding schools. A total number of 50 secondary schools in Morogoro municipality and 43secondary schools in Kilosa district served as a sampling frame from which the sample was drawn. A total of eight secondary schools, that is; four government and four private schools located in urban and rural areas were selected randomly to constitute a sample. To acquire a total sample of 405, stratified sampling technique was used, basing on age, gender and education level; then 50 up to 51 students were selected in each school by simple random selection without replacement. The sample size was computed using Barlett et al., [16].

$N=(Z^2P(1-p))/d^2$

Where N= estimated sample size,

d= precision level (acceptable error; 0.05),

P= proportion of population (If unknown, 0.5),

Z= Confidence interval (1.96).

N = (1.96)2 x 0.5 (1-0.5) = 384

(0.05)2

DRP = average dropout rate across all subjects (5%)

Substituting for this will be;

N= (385)/ (1-0.05) = 405

Therefore, the sample size was 405 respondents

Blood glucose and blood pressure measurements

Capillary blood (plasma) sample was collected for random blood glucose measurement using standardized Gluco Plus machine (Glucometer Type 25 KB JPG). Hyperglycemia was diagnosed using Random Blood Glucose ≥11.1 mmol/L [17]. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured from mid-upper-arm of the left side while the students were sitting and relaxed for 10 minutes before the actual measurement, using a standardized digital blood pressure (BP) device (Omron Digital HEM-907, Tokyo, Japan). Two BP measurements were taken within an interval of five minutes. Average systolic and diastolic BP was recorded in mmHg and was used for analysis. (Table 1, 2)

Assessment of determinants of T2DM and hypertension

BMI for age

Weight was measured using standard weighing scale (digital electronic SECA scale; Model 8811021659, Germany) that was kept on a firm horizontal surface. The subject was weighed without shoes on and with light clothing and the weight was recorded to the nearest0.1kg. Height was measured using a stadiometer (Model No PE-AIM-101-USA) and recorded to the nearest 0.1cm. Subjects were requested to stand upright without shoes on with their back kept against the wall and heels put together in a V-shape and looking forward. Age, sex, weight, and height information were entered in WHO AnthroPlus software and provided the BMI for age percentiles. The interpretation of BMI for age was based on World Health Organization criteria [18]. (Table 3)

Table 1: Cutoff-points for RBG measurement.

Diagnosis	RBG level (mmol/L)
Normal	≤7.8
Pre-diabetes	>7.8 - <11.1
Diabetes mellitus	≥11.1
Source: ADA (2016)	

Table 2: Blood pressure cutoff points for Hypertension among adolescents (≥13 years of age).

Hypertension status (stages)	Blood Pressure categories
Normal blood pressure	<120/<80mm Hg
Elevated blood pressure	120/<80 to 129/<80mm Hg
Stage 1 hypertension	130/80 to 139/89 mm Hg
Stage 2 hypertension	≥140/90 mm Hg
Source: AHA Guidelines for childhood hypertension (2017)	

Body fat percentage

Body fat was assessed by using Tanita bioelectrical impedance analysis (BIA) (Model, Tanita MC-180MA (Tanita, Tokyo, Japan), and students were required to remove their shoes, socks and metal materials like watches and ear rings. Two body fat measurements were taken at an interval of three minutes and the average body fat was used for analysis. The interpretation of body fat was based on World Health Organization criteria [19]. (Table 4,5)

Dietary diversity

Dietary assessment was done using a validated dietary diversity questionnaire [20]. Respondents were asked to recall all the foods consumed in the previous 24 hours prior to the survey and during the weekend. All snacks and foods eaten outside home and details of the ingredients added to each food were noted. Consumption of a particular food group scored 1, and non-consumed food group score of 0.We used the questionnaire with 12 aggregated food groups to capture micronutrients intake as well as consumption of sweets and beverages which are known to be associated with metabolic syndrome [21]. The food groups included cereals; white roots and tubers; vegetables; fruits; meat; eggs; fish and other sea foods; legumes, nuts and seeds; milk and milk products; oil and fats; sweets; spices, condiments and beverages. Dietary Diversity was divided into three categories and classified as low (≤3), medium (4 to 5) and high (≥6) [20].

Physical activity levels

Physical activities were assessed using a self-administered, 7-day recall physical activity questionnaire for adolescents (PAQ-A) which was translated into Kiswahili. The PAQ-A tool is designated and tested for adolescents

Table 3: Standard cut off points for children and adolescents 5-19 years of age.

Weight status	Body mass index percentiles
Underweight	Less than 5th percentile
Normal	5th -85th percentile
Overweight	85th - < 95th percentile
Obese	≥ 95th percentile
Source: WHO, 2009	

Table 4: Body fat status for Boys (14-19 years).

Body fat status	Body fat percentiles and percentages
Low body fat	< 3th percentile (0-7.99%)
Normal body fat	≥ 3 to < 85th percentile (8.0-15.99%)
Moderately elevated	≥ 85th to < 95th percentile (16.0-29.99%)
Elevated	≥ 95th to < 97th percentile (30.0-34. 99%)
Very elevated	≥ 97th percentile (35.0-42.99%)

Table 5: Body fat status for Girls (14-19 years).

Body fat status	Body fat percentiles and percentages
Low body fat	< 3th percentile (0-10.49%)
Normal body fat	≥ 3 to < 85th percentile (10.5-21.49%)
Moderately elevated	≥ 85th to < 95th percentile (21.5-32.99%)
Elevated	≥ 95th to < 97th percentile (33.0-36.49%)
Very elevated	≥ 97th percentile (36.5-42.99%)
Source: WHO, 2006	

approximately 14 to 19 years of age, developed by Kowalski et al., [22]. The questionnaire was administered in a classroom and students were asked to recall their activities from the day of the interview up to seven days backward. The questionnaire provided a summary of physical activity scores derived from eight items (spare time physical activities and activities conducted during weekend, evenings and right after school) each scored on a 5-point scale where a score of 1 indicated low physical activity, whereas a score of 5 indicated high physical activity [23].

Family history of diabetes and hypertension

Family history of diabetes and hypertension of the participants' first-degree relatives (mother, father, sisters or brothers) was collected by a pre-tested structured questionnaire. Students were required to put a tick in any of the first-degree relatives mentioned above if they had diabetes or hypertension.

Ethical Considerations

Ethical clearance to use human subjects was obtained from National Institute for Medical Research with reference number NIMR/HQ/R.8a/Vol.IX/3319 and Sokoine University of Agriculture. Permission was sought from regional administrative officer, respective District Executive Officers to conduct the study in the selected secondary schools. Parents, guardians and teachers signed a consent form to affirm their willingness or willingness of the children under their jurisdiction to participate in the study. All measurements were done by trained staff/personnel, and for the students who were identified with problems related to having pre-diabetes or hypertension; head teachers of the schools were informed so that they could inform the parents of the respective students to seek for medical care.

Statistical analysis

Data were analyzed using IBM SPSS version 21.0. Descriptive statistics such as frequencies and percentages were calculated and presented in tables and graphs. Chi-square (X2) test was used as a test of significance for categorical variables, and differences were considered significant at $p \leq 0.05$. Strength of association between the dependent and independent variables was obtained from Logistic regression which was used to evaluate the influence of the explanatory variables on the determinants within our study. All variables that were significant (p-value of ≤0.05) in the Univariate analysis were included in the multivariate models and a stepwise modeling procedure (backward conditional) was adopted to select the variables that were used to build the final model. Only variables with a p-value of ≤0.05 were retained in the final model. Multivariate analysis were performed following Bivariate analysis to adjust the effect of confounders using multiple logistic regression, both crude odds ratio (COR) and adjusted odds ratio (AOR) with 95% CI were reported.

Results

A total of 405 adolescent students were recruited in this study. About nine students refused to provide consent of participation after explaining the details of the study, 4 questionnaires were empty (complete non-responses) and 8 questionnaires were answered partially and thus; only 384 questionnaires were accurately completed and hence used in the analysis.

General characteristics and prevalence of T2DM and Hypertension of the population studied

Majority of the participants were in the age group of 14-16 years (79.7%) (n=306) and only 20.3% (n=78) were in the age group of 17-19 years. As for education level, adolescents were selected equally (33.3%) (n=128) in each level (Form 2, 3 and 4).

The prevalence of pre-diabetes according to the ADA criteria in the secondary school students was 5.2% (n=20). This prevalence was higher among males than females (6.3 % vs. 4.2%). The prevalence of pre-diabetes was also higher in those students with higher BMI. When location of the school and type of the school were considered, prevalence in urban setting was higher than twice that of the rural setting (7.3% vs. 3.1%), and was higher in students attending private schools compared to those attending government schools (9.9% vs. 0.5%). (Table 6)

Table 6: Prevalence of pre-diabetes according to the ADA criteria by sex, age, education level, BMI, body fat, school type and location.

Variables	Whole group N=384 (n)	(%)	Normal N=364 (n)	(%)	Pre-diabetes N=20 (n)	(%)	P-value
Sex							0.360
Male	192	50	180	93.8	12	6.3	
Female	192	50	184	95.8	8	4.2	
Age group							0.972
14-16 years	306	79.7	290	94.8	16	5.2	
17-19 years	78	20.3	74	94.9	4	5.1	
Education level							0.369
Form 2	128	33.3	124	96.9	4	3.1	
Form 3	128	33.3	121	94.5	7	5.5	
Form 4	128	33.3	119	93	9	7	
BMI for Age							0.000*
Normal	308	80.2	306	84.1	2	10	
Overweight/obese	76	19.8	58	15.9	18	90	
Body fat (BF)							0.152
Normal BF	34	8.9	34	9.3	0	0	
Elevated BF	350	91.1	330	90.7	20	100	
School type							0.000*
Government	192	50	191	99.5	1	0.5	
Private	192	50	173	90.1	19	9.9	
Location							0.066
Rural	192	50	186	96.9	6	3.1	
Urban	192	50	178	92.7	14	7.3	

*p≤0.05 indicating the significant variable

Prevalence of hypertension according to the ACC/AHA guideline in the population studied was 11.5%. This prevalence was slightly higher among female than men. The prevalence of hypertension was also higher in those students with higher BMI, and among those with elevated body fat. When location of the school and type of the school were considered, hypertension was higher in urban areas compared to rural areas (17. 2% vs. 5.7%), and was higher in students attending private schools compared to those attending government schools (14.6% vs. 8.3%). (Table 7)

Determinants of pre-diabetes

Binary logistic regression was performed using SPSS to assess significant determinants of pre-diabetes. Age, sex, school type, location of the school (area of residence), BMI status, body fat percentage, DDS, family history of diabetes, hypertension and physical activities were entered in the Univariate model. The model revealed that age, sex, DDS and physical activities were not significantly related to pre-diabetes, therefore were removed from the model. Significant variables remained in the model for further analysis by multivariate logistic regression adjusting for confounding factors by backward conditional. Significant determinants were overweight/obesity (OR 5.64; 95% CI 2.82–11.31), school type (OR 1.99; 95% CI 1.04–3.84) and elevated body fat (EBF) (OR 1.06; 95% CI 1.03 – 1.09). (Table 8)

Determinants of hypertension

Binary logistic regression was performed using SPSS to assess significant determinants of hypertension. Age, sex, school type, location of the school (area of residence), BMI status, body fat percentage, DDS, family history of diabetes, hypertension and physical activities were entered in the Univariate model. For Univariate model, age, sex and DDS were not significantly related to hypertension, therefore were removed from the model. Significant variables remained in the model for further analysis by multivariate logistic regression adjusting for confounding factors by backward conditional. Significant determinants that remained in the model were area of residence (OR 1.85; 95% CI 1.11 – 3.07), overweight/obese (OR 5.89; 95% CI 3.19 – 10.89), elevated body fat (EBF) (OR 1.14; 95% CI 1.09 – 1.19) and low physical activities (OR 1.58; 95% CI (1.35 – 3.48). (Table 9)

Discussion

This study reports prevalence and determinants of pre-diabetes and hypertension among secondary school adolescents in Morogoro region. The overall prevalence of pre-diabetes in the present study was 5.2 %; the prevalence being more than twice as much in urban compared to rural areas (7.3% vs. 3.1%).In this study, small percentage of the adolescents was pre-diabetic and none was diabetic. This could be due to the method used for assessing diabetes status, since random blood glucose test cannot be used alone as a standard method to diagnose diabetes. Therefore; methods like fasting blood glucose tests or use of Glycatedhaemoglobin (HbA1c) could be relatively more accurate to diagnose diabetes among this age group [24]. However, the observed pre-diabetic situation is alarming since the study population is still young and expected to perform productive and reproductive life in the future. The prevalence observed in this study are similar with other studies conducted in African countries and elsewhere. For example, a study conducted in Nigeria among school adolescents aged 10 to 19 years reported a prevalence rate of 4% [25]. Another study in United Arab Emirates, which assessed the prevalence rate and risk factors for pre-diabetes and diabetes among adolescents aged 11 to 17 years reported a prevalence rate of 5.4 % for pre-diabetes [26]. In the present study, we also found high prevalence of hypertension (11.5%, n=44); the prevalence being higher in urban compared to rural areas. The high prevalence of hypertension in this study could be due to the method used for assessing hypertension, since oscillometric devices have been found to overestimate both systolic and diastolic blood pressure. Therefore; methods like ambulatory blood pressure monitoring (specific validated device that assesses blood pressure every 20 to 30 minutes around the clock) in children and adolescents could be used as they could be relatively more accurate to diagnose hypertension among this age group [27]. High

Table 7: Prevalence of hypertension according to the ACC/AHA guideline by sex, age, education level, BMI, body fat, school type and location.

Variables	Whole group N=384 (n)	(%)	Normal BP N=290 (n)	(%)	Elevated BP N=50 (n)	(%)	Hypertension N= 44 (n)	(%)	P-value
Sex									0.764
Male	192	50	144	75	29	15.1	19	9.9	
Female	192	50	146	76	21	10.9	25	13	
Age group									0.137
14-16 years	306	79.7	239	78.1	32	10.5	35	11.4	
17-19 years	78	20.3	51	65.4	18	23.1	9	11.5	
Education level									0.112
Form 2	128	33.3	104	81.3	10	7.8	14	10.9	
Form 3	128	33.3	101	78.9	13	10.2	14	10.9	
Form 4	128	33.3	85	66.4	27	21.1	16	12.5	
BMI for Age									0.000*
Normal	308	80.2	258	89	32	64	18	40.9	
Overweight/obese	76	19.8	32	11	18	36	26	59.1	
Body fat (BF)									0.002*
Normal BF	34	8.9	34	11.7	0	0	0	0	
Elevated BF	350	91.1	256	88.3	50	100	44	100	
School type									0.052*
Government	192	50	155	80.7	21	10.9	16	8.3	
Private	192	50	135	70.3	29	15.1	28	14.6	
Location									0.000*
Rural	192	50	161	83.9	20	10.4	11	5.7	
Urban	192	50	129	67.2	30	15.6	33	17.2	
*p≤0.05 indicating the significant variable									

Table 8: Determinants of pre-diabetes in adolescents (Crude OR and Adjusted OR).

Determinants	n (%)	Crude OR (CI)	Adjusted OR (CI)
Age (years)			
14-16	16 (5.2)	1	1
17-19	4 (5.1)	1.02 (0.33 – 3.14)	0.98 (0.32 – 2.96)
Sex			
Female	8 (4.2)	1	1
Male	12 (6.3)	1.53 (0.61 – 3.84)	1.21 (0.58 – 2.53)
School type			
Government	1 (0.5)	1	1
Private	19 (9.9)	0.05 (0.01 – 0.36)	1.99 (1.04 – 3.84)*
Location			
Rural	6 (3.1)	1	1
Urban	14 (7.3)	1.43 (0.71 – 2.90)	0.41 (0.15 – 1.09)
BMI for Age			
Normal	2 (10)	1	1
Overweight/obese	18 (90)	1.30 (1.15 – 1.48)	5.64 (2.82 – 11.31)*
Body fat percentage			
Normal BF	0 (0.0)	1	1
Elevated BF	20 (100)	1.10 (0.58 – 2.09)	1.06 (1.03 – 1.09)*
DDS			
Low	5 (12.5)	1	1
Medium	10 (4.4)	0.54(0.11 – 2.55)	0.42 (0.06 – 2.19)
High	5 (4.2)	1.79 (0.83 – 3.09)	0.93 (0.09 – 2.67)
Family history of diabetes			
No	17 (5.3)	1	1
Yes	3 (4.7)	0.73 (0.23 – 2.266)	3.21 (0.87 – 11.87)
Hypertension			
No	14 (4.1)	1	1
Yes	6 (13.6)	7.80 (2.71 – 22.44)	0.27 (0.09 – 0.75)
Physical activities			
Relatively high	1 (0.5)	1	1
Medium	4 (5.1)	0.79 (0.45 – 1.64)	0.73 (0.41 – 1.49)
Low	15 (3.9)	1.48 (0.69 – 3.18)	0.98 (0.65 – 2.19)

* p≤0.05 indicating the significant determinant, binary logistic regression considering the simultaneous effect of all the explanatory variables

prevalence of hypertension could also be due to the fact that, adolescents living in the urban areas were living a more sedentary lifestyle that contributed to higher rates of overweight and obesity which was a noticeable risk factor for hypertension and pre-diabetes in the study. The prevalence obtained in the current study was partially in line with findings from other studies performed in different populations of children and adolescents in other countries. A systematic review and meta-analysis of data from 25 studies in Africa found a pooled prevalence of elevated blood pressure of 5•5% and a pooled prevalence of slightly elevated blood pressure of 12•7% in adolescents aged 10-19 years [28]. Also, the prevalence of hypertension in children and adolescents in developing countries has been established through systematic reviews to be between 1 and 5% [6, 7].

The present study showed a positive association between overweight and obesity and the two NCDs. Indeed, overweight and obese adolescents were at five time's higher risk for pre-diabetes and hypertension. Overweight and obesity were related with majority of cardiovascular diseases such as hypertension, asthma, coronary heart diseases and also diabetes [29]. These effects are not only for adults above 40 years of age, but they also occur among youths and in young adolescents. A number of epidemiological studies from Africa and other regions have previously reported this link between elevated blood pressure and increased BMI (obesity and overweight) both in adults, children and adolescents [28, 30]. Thus; increased BMI is an important risk factor for elevated blood pressure in adolescents in Africa. Since it is a modifiable risk, efforts should be directed towards healthy lifestyle at this young age.

It has also been observed in the current study that, adolescents with elevated body fat had increased risk for pre-diabetes and hypertension. Female adolescents were having higher proportions of body fat compared to their male counterparts, however; gender was not a risk factor for being pre-diabetic or hypertensive. This is because, naturally, the percentage of essential body fat for women is greater than that for men, due to the demands of child bearing and other hormonal functions [31]. These findings can be supported by other previous researchers; for-example [32], reported that, excess body fat in adolescents increases the risk of development of several medical conditions during adulthood, including insulin resistance, adult-onset T2DM and cardiovascular problems such as hypertension, heart diseases and stroke.

Other significant determinant that was observed to be associated with hypertension was insufficient physical activity levels. Adolescents who were physically inactive were more likely to have elevated blood pressure but not with blood glucose. The observed lack of association between sedentary lifestyle with elevated blood glucose levels could be due to the low prevalence of pre-diabetes observed or due to diagnosis criteria used, that is random blood glucose. Future studies should use HbA1C test which reveals blood glucose levels for the past three months and it is not affected by the last consumed meal of which is more accurate than the random blood glucose test [24]. In addition, objective physical activity assessment may be used instead of the subjective method of using questionnaire which could be subjective to recall bias. The present study is in contrast to the previous study conducted in Brazil among school adolescents (15-19 years) where the most prevalent risk factors for elevated blood pressure and hypertension were physical inactivity [33].

In our study, living in urban areas and studying in private schools were also positively associated with hypertension and pre-diabetes, respectively. The possible explanation for this is the variation in their socioeconomic status. Adolescents living in urban areas may be from wealthier households and hence; due to their higher socioeconomic status (SES) these children might have engaged in lifestyles that increased their risks for hypertension. Although, not explored enough in this study, wealthier families are more likely to consume energy-dense foods and drinks, and high salty snacks; thus in combination with insufficient physical activities they are more likely to become overweight/obese and hence have greater risk for diabetes and hypertension.

Table 9: Determinants of hypertension in adolescents (Crude OR and Adjusted OR).

Determinants	n (%)	Crude OR (CI)	Adjusted OR (CI)
Age (years)			
14-16	35 (11.4)	1	1
17-19	9 (11.5)	1.01 (0.46 – 2.20)	1.28 (0.59 – 2.79)
Sex			
Female	25 (13)	1	1
Male	19 (9.9)	1.36 (0.72 – 2.57)	0.96 (0.53 – 1.71)
School type			
Government	16 (8.3)	1	1
Private	28 (14.6)	1.88 (0.98 – 3.59)	1.50 (0.89 – 2.54)
Location			
Rural	11 (5.7)	1	1
Urban	33 (17.2)	3.42 (1.67 – 6.98)	1.85 (1.11 – 3.07)*
BMI for Age			
Normal	18 (40.9)	1	1
Overweight/obese	26 (59.1)	8.38(4.28 – 16.40)	5.89(3.19 – 10.89) *
Body fat percentage			
Normal BF	0 (0.0)	1	1
Elevated BF	44 (100)	1.25(0.79 – 1.97)	1.14(1.09 – 1.19)*
DDS			
Low	5 (12.5)	1	1
Medium	23 (10.2)	1.37(0.31 – 4.19)	1.09 (0.37 – 3.19)
High	16 (13.4)	1.36 (0.69 – 2.69)	1.01 (0.49 – 2.09)
Family history of hypertension			
No	36 (11.3)	1	1
Yes	8 (12.5)	1.46 (0.64 – 3.36)	1.13 (0.49 – 2.55)
Pre-diabetes			
No	38 (10.4)	1	1
Yes	6 (30)	1.04 (0.42 – 2.60)	0.27 (0.09 – 0.75)
Physical activities			
Relatively high	1 (0.3)	1	1
Medium	5 (1.3)	0.98 (0.49 – 4.68)	0.73 (0.41 – 4.49)
Low	38 (9.9)	1.98 (1.65 – 5.49)	1.58 (1.35 – 3.48)*

*p≤0.05 indicating the significant determinant, binary logistic regression considering the simultaneous effect of all the explanatory variables

Several studies have shown that, prevalence of metabolic syndrome in adolescents (10-19 years) significantly increases with high SES in both developing and developed countries [34, 35]. A systematic review conducted by [36], in sub-Saharan Africa (SSA) among children and adolescents aged 5-19 years, reported a positive association between overweight/obesity and SSA children of higher SES probably due to increased sedentary behaviors and increased accessibility to packaged foods high in sugars and saturated fats, more affordable to families of higher SES or living in urban settings. Thus; the determinants observed are modifiable, hence efforts should be directed towards healthy lifestyle at this young age.

Conclusions

Moderate prevalence of pre-diabetes and higher rates of hypertension were observed among adolescents in the current study. Among the identified determinants for hypertension and pre-diabetes; overweight and obesity, elevated body fat, and physical inactivity were the modifiable determinants. Although majority of the adolescents consumed foods high in fat and sugars, dietary diversity did not contribute to the observed prevalence of pre-diabetes or hypertension.

Monitoring of adolescent's nutrition and health status is very crucial, and the health sector should take the lead in routine health and nutrition assessment, monitor level of physical activities, dietary practices, and nutritional status among day and boarding scholars as both of them are at risk. Further research should be conducted to establish eating patterns and exposure to obesogenic environments and using more objective assessments to ascertain the current findings.

Strengths and limitations of this study

This cross-sectional study allowed for data collection of a large population-based sample of adolescents who reside in Morogoro, Tanzania. The study contributed to the limited data on the prevalence of diabetes and hypertension diagnosis among adolescents and highlighted potential determinants. The results of this study can also be used to highlight vulnerable groups where interventions and increased screening may be beneficial.

For limitations, the method used for assessing diabetes status in this study cannot be used as a standalone method to diagnose diabetes. Therefore; methods like fasting blood glucose tests or use of Glycatedhemoglobin (HbA1c) could be used instead. The use of questionnaire to assess physical level of activities is highly subjective to bias hence objective physical activity assessment could be used instead of the subjective method.

Author contributions

KM conceived the idea, coordinated all research, participated in the data collection, data management, and drafted the manuscript. AM and KR conceived the idea, supervised the study procedures and reviewed the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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