Association Between Dietary Consumption, Anthropometric Measures And Body Composition Of Rural And Urban Ghanaian Adults; A Comparative Cross Sectional Study.

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Abstract

Background: Overweight and obesity have become threats to public health in all regions across the globe. Policies to regulate the food environment and promote healthy food consumption can reduce the prevalence obesity but in Ghana there is not enough data to elicit a policy response. This study assessed the association between dietary consumption, anthropometric measures, body composition and physical activity among rural and urban Ghanaian adults.

Methods: This was a cross-sectional study involving 565 Ghanaian adults. Structured questionnaires were used to collect socio-demographic information. Dietary consumption was assessed using household food frequency questionnaire and 24-hour recall. Height, weight, BMI, waist circumference and body composition of all participants were also measured. The World Health Organization’s Global Physical Activity Questionnaire (GPAQ) was used to assess physical activity levels. Mann Whitney U test was used to analyze differences in anthropometric measurements, body composition and dietary consumption among rural and urban participants. Principal component analysis was used to analyze household food frequency data and nutrient analysis template was used to analyze 24-hour recall. Chi-square was used to measure differences in obesity prevalence by community and gender. Multinomial logistic regression was used to model the risk factors associated with obesity.

Results: The prevalence of overweight and obesity using BMI were 29.9 and 22.9 respectively. The use of waist circumference measurement resulted in the highest overall obesity prevalence of 41.5%. Prevalence of obesity was higher among females compared to males across all measures with the exception of visceral fat that showed no significant difference. Four different patterns were derived from principal component analysis. Among urban participants, component 3 (staple pattern) showed a significant negative correlation with visceral fat ($r = -0.186$, p-value $0.013$) and BMI ($r = -0.163$, p-value $0.029$). Multinomial logistic regression showed that males (AOR 19.715, CI 9.723-39.978, p-value $< 0.001$) had higher odds of being of normal weight compared to females.

Conclusion: Prevalence of overweight and obesity continue to rise in Ghana, especially among females. Public education and screening as well as interventions that regulate the food environment and make affordable and available healthy food options are needed to control the rise in obesity
prevalence.

Background

Obesity is a major cause of cardiovascular and chronic diseases which contribute to about 71% of all global deaths [1]. Obesity continues to increase across all ages and regions all over the world and children are also an important risk group [2]. In sub-Saharan Africa where about 42% of the population live below the poverty line, prevalence of obesity continues to rise although and a strong positive association has consistently been observed between socio-economic status and obesity [3]. Annually, about 2.8 million people die from overweight or obesity [1]. Once a problem of the developed world, obesity is now on the increase in developing countries and Ghana is no different exception. It is forecasted that by 2030, obesity will be more prevalent in developing countries [4]. and Dake [5] projects prevalence among Ghanaian women aged 15–49 years to reach 15.1% by 2023.

Developing countries are faced with a double burden of disease not only at country and community levels but also within households. This implies that in a household where adults are obese, it is possible to find undernourished children who struggle to achieve optimum growth z-scores for their age [1]. Stunting and wasting are risk factors for obesity in later years and this situation creates the vicious a cycle of malnutrition in the sub region [6]. Genetic susceptibility, high socio-economic status, excess caloric consumption among other factors predict obesity but the current transition and trend is mainly driven by increased caloric intake and reduced physical activity levels. These that are associated with urbanization coupled with lack of policies to control a growing obesogenic food environment [7, 8]. Urbanization leads to reduced consumption of healthy staples and an obesogenic food environment makes readily available cheaper priced energy dense foods [9]. Energy balance is key to the maintenance of body weight. and Consumption of more calories than what is utilized through metabolic and physical activities leads to weight gain. These excess calories, stored in the body as fat can impair proper health and function [10]. Additionally, inadequate intakes and deficiencies of micronutrients such as zinc are linked to obesity [11].
Consistently, studies have reported a higher prevalence of obesity among urban populations compared to rural ones. Part of this may be due to differences in physical activity levels, socio-economic status and food consumption patterns among rural and urban dwellers residents [12, 13]. Gender differences have also been observed with females being more susceptible than males. Parity is one factor that puts women at higher risk than men [14, 15].

Body Mass Index (BMI) is the usual screening tool for determining obesity among populations [15]. Build-up of body fat positively correlates with total body mass and hence therefore weight gain indices are used as determinants of body fat [16]. It however, has limitations of not being able to accurately predict adiposity [17]. BMI, when used in combination with other diagnostic tools such as waist circumference and Body Impedance Analysis (BIA) provides in-depth information about adiposity as well as presumed cardio-metabolic risk. Increased body fat is a prominent risk factor for type 2 diabetes, stroke, hypertension and heart disease [18, 19]. Combining these tools to screen for obesity among populations may reveal higher prevalence than what is reported by most studies.

The Ghana 2014 Demographic Survey (GDHS) indicates that the prevalence of overweight and obesity among men and women is 15.7% and 40.1% respectively [20]. In Ghana, some recent studies have been conducted within various Ghanaian populations to ascertain the prevalence of overweight and obesity but these studies have mainly focused on urban females. Very few have been community based. [5, 20]. Most of these studies have also been done in Greater Accra region which is the capital of Ghana. An example is the Women’s Health survey which found a 62.2% prevalence of overweight and obesity among urban women living in Accra [20]. Few studies have assessed consumption patterns associated with obesity, compared rural and urban individuals as well as included body composition measurements. Assessment of all these parameters will provide more insight into the obesity menace and consumption patterns associated with it. Information on consumption patterns are necessary to formulate policies that support the selection and consumption of healthier food choices as a means to curb the obesity menace.

This study is part of a big study titled “Researching the Obesogenic Food Environment, its Drivers and Potential Policy levers in Ghana and South Africa (ROFE). The project consists of three phases and the
findings presented here are from the phase one aspect of the project. The main aim of this study was to compare the prevalence of obesity among rural and urban dwellers residents using BMI, waist circumference and body composition measures and to determine consumption factors associated with obesity.

Methods
This was a cross-sectional study that involved the use of interviewer-administered structured questionnaires to collect information on socio-demographics. Sociodemographic data collected included age, sex and level of education. Weight, height, waist circumference and body composition measurements of all participants were taken. The height of each participant was entered in to the body composition analyzer which was used to measure the weight and other body components. Body Mass Index (BMI) was generated from the weight and height measurement (weight in kilograms/height in metres²).

Study site
The study was conducted in two communities in the Ashanti region of Ghana; Ahodwo, an urban community and Ejuratia, a rural community. Data collection was done by visiting households within the selected communities.

Sample size and sampling
The study involved a total of 565 participants. Systematic sampling was used to select households and any household member either male or female eighteen years and above was included. One household was randomly selected within each house. For each household, only one member was included and where there were both a male and a female who qualified, the male was selected to ensure gender balance as it was more difficult to find males in households. Additionally, the first adult seen in the household was the one selected to be part of the study unless he or she refused and another was selected. For the rural community after a random start, every third house qualified to be included in the study and every fifth house was chosen for the urban community. The difference in intervals was due to the smaller sample frame in the rural area compared to the urban area.
Households who declined to participate in the study were excluded.

Dietary consumption
Twenty four-hour recall and household food frequency was used to collect information on food consumption. The household food frequency consisted of commonly consumed food groups with specific foods listed under each food group. Participants were also asked of any likely food under each of the food groups they had consumed that were not captioned. Participants were to indicate how often they consumed each food item. One twenty-four-hour recall was taken for each participant to assess previous day food consumption. Principal component analysis was used to generate patterns of consumption among participants. Nutrient analysis template; a food composition table consisting of only Ghanaian foods was used to estimate quantity of nutrient intakes and dietary diversity from the 24-hour recall.

**Body composition and anthropometric measurement**

Participants were made to remove their footwear and put on light clothing prior to the taking of anthropometry. Height was taken using Seca stadiometre, model 213 with participants standing up right with feet together and hands at the sides. Weight and body composition were measured using the Omron body composition monitor, model HBF-514. Height, gender and age of participants were entered into the body composition monitor before participants were made to stand on it. This generated body composition results as well as BMI of participants. Body mass index (kg/m²) was classified using WHO criteria for adults; < 18.5 underweight, 18.5–24.9 normal, 25–29.9 overweight and > 30 obese. Visceral fat of > 9% was definitive of central obesity and body fat cut offs were based on gender and age of participants as suggested by Gallager [19, 21]. Waist circumference was taken with a flexible tape measure. Central obesity was defined as waist circumference of >88cm for females and > 102cm for males.

**Assessment of physical activity**

The World Health Organization’s Global Physical Activity Questionnaire (GPAQ) was used to assess the physical activity levels of study participants. The total minutes of different level of physical activities performed by participants in a typical week was calculated from the number of days in a week for engaging in such activity and the time spent on the particular activity. The activity ranged from moderate to vigorous intensity activity or sports as well as walking and bicycling as a means of
travelling. Total time for vigorous intensity activities for the week was multiplied by 8 while moderate intensity activities, walking and bicycling were multiplied by 4 to convert the minutes to metabolic equivalents. The World Health Organization (WHO) suggests a minimum of 600 metabolic equivalents per week for adults as a way to promote cardiometabolic health. Participants were stratified into two groups based on those meeting the recommendation and those not meeting the recommendation.

**Ethical clearance**

Ethical clearance for the study was granted by the Council for Scientific and Industrial Research (CSIR), Ghana; RPN 011/CSIR-IRB/2017. Written permission was sought from local government officials before data collection and all participants signed or thumb printed an inform consent form to indicate voluntary participation.

**Statistical Analysis**

Statistical Package for Social Sciences (IBM SPSS) 23 was used for data analysis. Normality test revealed that data was positively skewed. Mann Whitney U test was used to compare the median age, body composition and nutritional intakes among rural and urban participants. Kruskal Wallis test was used to compare the median nutrient intakes among underweight, normal, overweight and obese participants. Spearman correlation was used to determine the relationship between BMI and body composition measures. Principal component analysis was used to determine the patterns of consumption. Multinomial logistic regression was used determine the predictors of obesity measured by waist circumference. Waist circumference was used because it determined the highest prevalence of obesity and strongly correlated positively with all other body composition measures. A p-value of < 0.05 was set as statistically significant.

**Results**

A total of 565 participants took part consented to be part of this study; 292 from rural and 272 from urban. The median age of participants was 40(26) years and there was no statistical difference between rural and urban participants. The overall median body mass index of participants was 25.6(7.4) with urban dwellers residents recording a significant higher value. Visceral fat was also significantly higher for urban dwellers participants compared to rural participants. Calorie, carbohydrate and fibre intakes were significantly higher among rural participants. while Urban
participants were shown to consumed higher amounts of vitamin A. Other nutrients did not show any significant difference. Rural participants had higher metabolic equivalents compared to their urban counterparts. Table 1 shows socio-demographics, nutritional intake and body composition characteristics of study participants.

Table 1. Descriptive Statistics
### DESCRIPTIVE VARIABLES

| Total N=565 | STATISTICS AND BALANCE CHECK |
|-------------|-------------------------------|
|             | RURAL n=292 | URBAN n=272 | P-VALUE |
| Age         | 40(26)      | 40(26)      | 38(26)  | 0.737  |
| Gender      |             |             |         |
| Male        | 113(19.8)   | 43(14.7)    | 70(25.7)| 0.001* |
| Female      | 452(79.2)   | 249(85.3)   | 202(74.3)|        |
| Level of Education |         |             |         |
| No formal education | 98(17.2) | 60(21.4)    | 38(16.7)| <0.001* |
| Primary     | 50(8.8)     | 27(9.6)     | 23(10.1)|        |
| Junior secondary | 176(30.8)| 120(42.9)  | 56(24.7)|        |
| Senior secondary | 132(23.1)| 64(22.9)   | 66(29.1)|        |
| Tertiary    | 53(9.3)     | 9(3.2)      | 44(19.4)|        |
| Weight (kg) | 65.9(20.2)  | 62.4(18.3)  | 69.9(20.65)| <0.001* |
| Height (cm) | 159.3(9.83) | 150.8(8.60)| 160.5(11.2)| <0.001* |
| BMI (kg/m²) | 25.6(7.40)  | 25.0(6.7)   | 26.1(7.65)| 0.016* |
| Waist       | 87.4(19.80) | 87.0(17.55)| 89.0(22.0)| 0.115  |
| Muscle mass (cm)&nbsp; | 26.9(6.13) | 26.8(5.05) | 27.0(6.95)| 0.526  |
| Body fat    | 35.7(15.22) | 35.2(14.33)| 36.9(16.35)| 0.341  |
| Visceral fat | 7.0(4.0)   | 7.0(4.0)    | 7.0(5.0)| 0.015* |
| Energy intake (Kcal) | 1434.0(951.1)| 1601.4(999.04) | 1330.7(899.84)| 0.004* |
| Fat (g)     | 42.5(44.08) | 44.2(50.8) | 41.0(39.2)| 0.781  |
| Protein (g) | 42.6(32.5)  | 42.6(32.7)  | 42.9(33.06)| 0.838  |
| Carbohydrate (g) | 208.0(137.0) | 223.5(128.8) | 187.9(137.6)| 0.001* |
| Fibre (g)   | 18.3(13.3)  | 20.0(13.8)  | 16.9(13.5)| 0.001* |
| Sugar (g)   | 29.6(41.4)  | 28.0(35.6)  | 33.9(50.04)| 0.242  |
| Folate (µg) | 225.6(240)  | 234(241.2)  | 216.4(237.0)| 0.222  |
| Iron (mg)   | 9.2(6.6)    | 9.5(6.33)   | 8.8(6.8)| 0.569  |
| Zinc (mg)   | 5.92(4.7)   | 6.1(4.9)    | 5.7(4.7)| 0.860  |
| Vitamin B₁₂ (µg) | 1.76(3.2) | 1.92(3.81) | 1.73(2.64)| 0.296  |
| Vitamin A (µg) | 120.6(139.8)| 111.2(121.6)| 128.8(165.3)| 0.022* |
| Vitamin E (mg) | 5.6(6.4)   | 5.6(6.4)    | 5.5(6.3)| 0.658  |
| Saturated fat (g) | 12.2(15.3) | 11.1(15.8) | 13.1(14.6)| 0.143  |
| Monounsaturated fat (g) | 14.7(18.3) | 14.8(20.33) | 14.7(17.0)| 0.930  |
| Polyunsaturated fat (g) | 7.9(8.4)   | 8.37(9.17)  | 7.3(7.7)| 0.285  |
| Dietary diversity score | 6.0(2.01) | 6(3)        | 6(2.01) | 0.118  |
| Physical activity (total metabolic equivalent per week) | 600(3280) | 960(4360) | 360(1890) | <0.001* |

Some variable responses were missing and therefore does not sum up to 565. *Significant at p-value <0.05

Some variable responses were missing and therefore does not sum up to 565. *Significant at p-value <0.05
Using BMI, there was no difference in the prevalence of obesity among rural and urban participants. Visceral and body fat cut offs showed a higher prevalence of obesity in urban compared to rural participants. Prevalence of obesity by all parameters was higher among females compared to males with the exception of visceral fat that showed no difference. Table 2 and 3 shows the prevalence of obesity by community and gender respectively.

### Table 2. **Prevalence of obesity stratified by community and gender**

| Variable          | Total   | Rural n=292 | Urban n=272 | p-value | Male n=113 | Female n=452 | P-value |
|-------------------|---------|-------------|-------------|---------|------------|--------------|---------|
| **BMI**           |         |             |             |         |            |              |         |
| Underweight       | 9(1.6)  | 5(1.7)      | 4(1.5)      | 0.110   | 0(0)       | 9(2.0)       |         |
| Normal            | 247(43.3) | 140(48.3)   | 104(39.4)   | 74(67.3) | 171(38.4)  | <0.001*      |         |
| Overweight        | 171(29.9)| 87(30.0)    | 83(31.4)    | 25(25.7) | 145(32.6)  | <0.001*      |         |
| Obese             | 131(22.9)| 58(20.0)    | 73(27.7)    | 11(10.0) | 120(27.0)  | <0.001*      |         |
| **Visceral fat**  |         |             |             |         |            |              |         |
| Normal            | 434(76.0)| 246(85.1)   | 184(71.0)   | <0.001* | 84(77.1)   | 347(78.9)    | 0.385   |
| Obese             | 118(20.7)| 43(14.9)    | 75(29.0)    | 25(22.9) | 93(21.1)   | <0.001*      |         |
| **Body fat**      |         |             |             |         |            |              |         |
| Underweight       | 48(8.4) | 29(10.0)    | 19(7.3)     | 0.023*  | 22(20)     | 26(5.9)      |         |
| Normal            | 198(34.7)| 117(40.3)   | 80(30.8)    | 49(44.5) | 149(33.8)  | <0.001*      |         |
| Overweight        | 130(22.8)| 66(22.8)    | 64(24.6)    | 20(18.2) | 110(24.9)  | <0.001*      |         |
| Obese             | 175(30.6)| 78(26.9)    | 97(37.3)    | 19(17.3) | 156(35.4)  | <0.001*      |         |
| **Waist circumference** |       |             |             |         |            |              |         |
| Normal            | 171(29.9)| 95(33.3)    | 76(33.0)    | 0.976   | 81(79.4)   | 90(21.8)     | <0.001* |
| Overweight        | 107(18.7)| 60(21.1)    | 47(20.4)    | 9(8.8)  | 98(23.7)   | <0.001*      |         |
| Obese             | 237(41.5)| 130(45.6)   | 107(46.5)   | 12(11.8) | 225(54.5)  | <0.001*      |         |

Some variable measurements were missing and may therefore not sum up to 565. *Significant at p-value <0.05.

Table 3 shows the community and weight status of study participants by their physical activity category. Across all measures, with the exception of visceral fat, higher proportion of overweight and obese participants did not meet WHO recommendation for physical activity per week. A higher proportion of rural and female participants did not compared to urban meet the WHO recommendation
for physical activity.

Table 3. Community and weight status by physical activity category

| Variable | Total | Not meeting WHO recommendation | Meeting WHO recommendation | P-value |
|----------|-------|-------------------------------|-----------------------------|---------|
| BMI      |       |                               |                             |         |
| Underweight | 9(1.7) | 5(1.9)                        | 4(1.5)                      |         |
| Normal   | 237(43.9) | 95(35.8)                    | 142(51.6)                   | 0.003   |
| Overweight | 167(30.9) | 91(34.3)                     | 76(27.6)                    |         |
| Obese    | 127(23.5) | 74(27.9)                     | 53(19.3)                    |         |
| Visceral fat |       |                               |                             |         |
| Normal   | 419(78.5) | 187(71.6)                    | 232(85.0)                   | <0.001  |
| Obese    | 115(21.5) | 74(28.4)                      | 41(15.0)                    |         |
| Body fat |       |                               |                             |         |
| Underweight | 46(8.6) | 17(6.5)                       | 29(10.6)                    |         |
| Normal   | 192(35.9) | 81(31.0)                     | 111(40.5)                   | 0.007   |
| Overweight | 125(23.4) | 63(24.1)                     | 62(22.6)                    |         |
| Obese    | 172(32.1) | 100(38.3)                    | 72(26.3)                    |         |
| Waist circumference |       |                               |                             |         |
| Normal   | 166(33.3) | 62(25.8)                     | 104(40.2)                   |         |
| Overweight | 104(20.8) | 48(20.0)                     | 56(21.6)                    | 0.001   |
| Obese    | 229(45.9) | 130(54.2)                    | 99(38.2)                    |         |
| Community |       |                               |                             |         |
| Rural    | 280(51.1) | 115(42.6)                   | 165(59.4)                   | <0.001  |
| Urban    | 268(48.9) | 155(57.5)                   | 113(40.6)                   |         |
| Gender   |       |                               |                             |         |
| Male     | 226(84.0) | 211(75.6)                     | 68(24.8)                    | 0.010   |
| Female   |       |                               |                             |         |

WHO recommendation is equivalent to 600 or more of Metabolic equivalents per week.

Table 4-6 shows the difference in nutrient intakes among BMI, waist circumference and body composition categories. Most macro and micro nutrient intakes were significantly higher among the obese group in the rural sample but little differences were observed for the urban sample.

Table 4. Nutrient intakes for BMI, waist circumference and body composition categories.
### Table 5. Differences in micronutrient intakes for BMI, waist circumference and body composition categories.

| Rural | Energy | Protein | Fat | CHO | Fibre | Sugar | Energy | Protein |
|-------|--------|---------|-----|-----|-------|-------|--------|---------|
| Underweight | 1056.5 (697.5) | 38.7 (52.6) | 31.2 (18.6) | 164.4 (116.6) | 13.1 (10.3) | 12.1 (47.5) | 1126.1 (862.5) | 29.2 (26.1) |
| Normal | 1320.5 (844.8) | 35.8 (30.2) | 35.0 (39.1) | 200.3 (128.6) | 18.1 (11.1) | 23.2 (27.1) | 1209.2 (758.9) | 41.0 (35.1) |
| Overweight | 1669.2 (955.6) | 51.4 (33.1) | 50.3 (47.9) | 233.5 (118.6) | 21.7 (12.9) | 36.7 (45.2) | 1414.0 (990.8) | 41.0 (33.6) |
| Obese | 2105.3 (695.2) | 50.7 (26.8) | 64.8 (53.4) | 280.7 (160.7) | 25.3 (13.2) | 44.3 (46.7) | 1448.1 (962.0) | 46.8 (33.8) |
| P-value | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 | 0.006 | 0.336 |

| Visceral Fat | |
| Normal | 1514.0 (942.0) | 42.1 (33.9) | 41.8 (45.7) | 217.2 (127.9) | 19.4 (13.6) | 26.6 (35.5) | 1279.3 (920.8) | 41.1 (34.0) |
| Obese | 2060.0 (984.5) | 41.2 (37.8) | 66.4 (76.4) | 277.3 (134.2) | 23.5 (11.1) | 41.8 (52.8) | 1448.1 (845.8) | 45.0 (30.4) |
| P-value | <0.001 | 0.046 | 0.018 | 0.003 | 0.016 | 0.007 | 0.064 | 0.299 |

| Body Fat | |
| Underweight | 1421.4 (1103.6) | 41.2 (49.2) | 35.5 (42.0) | 187.7 (152.6) | 17.9 (17.6) | 19.7 (31.6) | 1322.4 (768.0) | 45.6 (37.9) |
| Normal | 1376.4 (814.6) | 38.1 (30.0) | 38.9 (47.3) | 212.3 (126.1) | 18.2 (10.9) | 25.4 (28.7) | 1209.2 (1028.1) | 38.0 (35.5) |
| Overweight | 1633.2 (930.3) | 48.1 (34.8) | 43.0 (46.2) | 223.6 (120.2) | 21.0 (10.7) | 32.2 (30.4) | 1393.2 (859.7) | 47.7 (36.6) |
| Obese | 2048.0 (907.7) | 50.1 (29.7) | 61.7 (59.6) | 278.9 (168.0) | 24.6 (13.7) | 40.4 (54.3) | 1421.6 (871.1) | 42.9 (29.3) |
| P-value | <0.001 | 0.003 | 0.023 | <0.001 | 0.030 | 0.005 | 0.070 | 0.432 |

| Waist Circumference | |
| Normal | 1403.7 (856.5) | 39.3 (30.2) | 36.8 (43.6) | 212.9 (128.6) | 19.5 (12.0) | 24.7 (29.6) | 1327.4 (902.1) | 40.1 (34.2) |
| Overweight | 1366.4 (978.9) | 34.0 (40.2) | 34.9 (39.2) | 212.5 (156.8) | 18.3 (13.7) | 30.4 (33.8) | 1379.6 (902.7) | 46.8 (40.9) |
| Obese | 1712.3 (1054.3) | 48.1 (30.2) | 52.6 (55.8) | 238.0 (129.9) | 21.8 (13.6) | 32.2 (41.9) | 1404.9 (879.8) | 42.2 (28.2) |
| P-value | 0.001 | 0.008 | 0.005 | 0.024 | 0.127 | 0.090 | 0.290 | 0.767 |

Significant p-values are in bold
| BMI         | Folate | Iron | Zinc | Vit. B12 | Vit.A | Vit. E | DDS | Folate | Iron |
|-------------|--------|------|------|----------|-------|--------|-----|--------|------|
| Underweight | 93.2 (227.1) | 6.7 (6.6) | 4.3 (4.2) | 2.4 (15.7) | 37.1 (93.1) | 4.5 (3.9) | 6(4) | 137.6 (208.4) | 7.0 (8.2) |
| Normal      | 193.7 (195.8) | 8.5 (6.6) | 5.1 (4.4) | 16.0 (3.5) | 98.5 (105.9) | 4.7 (5.4) | 6(3) | 214.9 (225.7) | 8.4 (6.8) |
| Overweight  | 271.4 (273.0) | 10.1 (6.4) | 6.5 (5.1) | 2.7 (4.1) | 118.4 (130.4) | 6.3 (7.5) | 6(3) | 216.7 (275.6) | 9.2 (6.1) |
| Obese       | 315.6 (224.1) | 12.1 (5.2) | 7.2 (4.1) | 1.7 (5.5) | 149.6 (131.0) | 6.8 (5.6) | 7(4) | 221.4 (2.2) | 9.1 (8.2) |
| P-value     | <0.001 | <0.001 | <0.001 | 0.034 | 0.001 | 0.008 | 0.189 | 0.544 | 0.397 |

| Visceral Fat | Normal | 230.5 (260.4) | 9.2 (6.4) | 6.0 (4.9) | 2.0 (3.7) | 107.6 (120.5) | 5.5 (6.5) | 6.0 (3.0) | 224.5 (236.3) | 8.4 (7.1) |
|             | Obese  | 272.6 (172.0) | 12.0 (5.6) | 6.9 (4.0) | 1.6 (4.7) | 135.7 (146.0) | 6.6 (5.7) | 7.0 (3.0) | 199.7 (244.9) | 9.7 (5.4) |
| P-value     | 0.200  | 0.014 | 0.037 | 0.879 | 0.155 | 0.526 | 0.537 | 0.940 | 0.178 |

| Body Fat    | Underweight | 176.6 (226.5) | 9.4 (6.9) | 5.2 (4.1) | 1.5 (4.1) | 92.7 (124.7) | 5.6 (5.6) | 6.0 (3.0) | 240 (243.8) | 9.0 (6.1) |
|             | Normal     | 208.3 (237.3) | 8.7 (6.5) | 5.5 (4.4) | 1.8 (3.7) | 102.1 (116.4) | 4.8 (6.5) | 6.0 (3.0) | 197.9 (227.0) | 7.6 (6.0) |
| P-value     | 0.006 | 0.004 | 0.014 | 0.092 | 0.091 | 0.201 | 0.608 | 0.276 | 0.242 |

| Waist Circumference | Normal | 209.5 (283.8) | 9.0 (6.7) | 5.7 (4.4) | 1.8 (3.1) | 101.3 (110.6) | 4.8 (6.8) | 6.0 (3.0) | 207.1 (196.7) | 8.9 (7.1) |
|                    | Overweight | 210.1 (212.8) | 8.7 (6.3) | 5.5 (5.0) | 1.4 (3.9) | 110.6 (117.4) | 4.7 (4.7) | 6.0 (4.0) | 237.6 (275.0) | 9.4 (7.3) |
| P-value             | 0.096 | 0.035 | 0.069 | 0.206 | 0.077 | 0.040 | 0.348 | 0.650 | 0.570 |

Significant P-values are in bold

Table 6. Differences in fat intake by body weight category.
Table 7 and 8 show principal component analysis of household food frequency. A total of four components were extracted for each community. The four components explained 32.4% and 30.9% of the total variance for rural and urban respectively. Table 8 and 9 show partial spearman correlation between the four components and body composition measures. Among urban participants component 3 (staple pattern) showed a negative correlation with BMI -0.163(0.029) and visceral fat -0.186(0.013).

**Table 7. Principal component analysis (PCA) of household food frequency (RURAL)**

| Food items in the PCA | Diverse diet | Vegetable | Non convenience pattern | Fast food |
|-----------------------|--------------|-----------|-------------------------|-----------|
| Rural | Urban |
| BMI | Saturated fatty acid | Monounsaturated fatty acid | Polyunsaturated fatty acid | Saturated fatty acid | Monounsaturated fatty acid |
| Underweight | 11.7(7.6) | 11.9(7.0) | 6.9(4.2) | 16.2(19.8) | 14.8(14.1) |
| Normal | 8.8(12.9) | 12.1(15.4) | 6.2(8.1) | 12.7(13.8) | 14.6(14.1) |
| Overweight | 12.5(17.5) | 17.8(22.8) | 9.5(9.9) | 12.5(17.2) | 13.9(14.1) |
| Obese | 18.2(19.0) | 22.5(25.0) | 12.1(9.3) | 14.5(14.0) | 16.1(14.1) |
| P-value | 0.009 | 0.001 | <0.001 | 0.794 | 0.507 |
| Visceral Fat | | | | |
| Normal | 11.0(15.4) | 14.4(19.0) | 8.0(8.4) | 13.2(15.2) | 14.8(14.1) |
| Obese | 13.8(21.5) | 21.6(29.0) | 12.4(13.3) | 12.2(15.4) | 14.1(14.1) |
| P-value | 0.170 | 0.086 | 0.032 | 0.626 | 0.906 |
| Body Fat | | | | |
| Underweight | 12.9(12.8) | 15.1(16.2) | 8.6(8.2) | 10.8(111.7) | 10.5(14.2) |
| Normal | 9.5(16.0) | 12.6(19.1) | 6.5(7.9) | 14.2(17.4) | 15.4(14.1) |
| Overweight | 11.3(13.0) | 14.0(21.7) | 11.3(13.1) | 13.0(15.7) | 13.8(14.1) |
| Obese | 13.9(19.5) | 20.4(27.3) | 13.9(19.5) | 13.1(13.4) | 14.9(14.1) |
| P-value | 0.311 | 0.046 | 0.006 | 0.585 | 0.566 |
| Waist Circumference | | | | |
| Normal | 11.6(13.4) | 12.9(18.5) | 7.5(7.4) | 12.3(13.3) | 14.8(14.1) |
| Overweight | 8.3(10.9) | 11.5(13.6) | 6.4(8.4) | 16.5(18.5) | 15.7(14.1) |
| Obese | 13.0(18.7) | 18.0(23.9) | 9.9(10.5) | 12.9(14.0) | 14.0(14.1) |
| P-value | 0.106 | 0.011 | 0.013 | 0.695 | 0.946 |

Significant P-values are in bold
| Item                                      | Convenience pattern |
|-------------------------------------------|---------------------|
| Instant noodles                          | 0.642               |
| Processed milk                           | 0.568               |
| Salty snacks                              | 0.556               |
| Sugar sweetened beverages                 | 0.555               |
| Tea or coffee                             | 0.531               |
| Meat                                      | 0.522               |
| Confectionery                             | 0.504               |
| Eggs                                      | 0.474               |
| Commercial bread                          | 0.455 -0.364        |
| Rice                                      | 0.433               |
| Vegetables raw fresh                      | 0.424 -0.365        |
| breakfast cereal                          | 0.42 0.322          |
| Organ meat                                | 0.418               |
| chicken                                   | 0.417               |
| friedfish                                 | 0.415 0.318         |
| sweets                                    | 0.404               |
| Margarine or butter                       | 0.358               |
| Processed meat                            | 0.34                |
| Legumes                                   |                     |
| Fish                                      |                     |
| Milk                                      |                     |
| Salted dried fish                         |                     |
| Diet beverages                            | 0.571               |
| Vegetables fried                          | 0.504               |
| Fast food                                 | 0.356 0.500 0.331   |
| Restaurant meals                          | 0.380 0.469 0.361   |
| Nuts                                      | 0.337 0.307         |
| Sugar                                     | 0.363 0.497         |
| Ready to eat meals                        | -0.377 -0.470       |
| Pasta                                     | 0.371 -0.310 -0.454 |
| Vegetables cooked                         | 0.434 0.320 -0.438  |
| Fried potatoes                            | 0.303 -0.367 -0.402 |
| Fruit                                     | 0.325               |
| Roots tubers                              |                     |

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Kaiser-Meyer-Olkin Measure of Sampling Adequacy 0.740, Bartlett's Test of Sphericity <0.001

Table 8. Principal component analysis (PCA) of household food frequency (URBAN)
| Food items in PCA                      | Diverse diet | Meat pattern | Staple pattern | Non- |
|----------------------------------------|--------------|--------------|----------------|------|
| eggs                                   | 0.606        |              |                |      |
| sweets                                 | 0.587        |              |                |      |
| confectionery                          | 0.573        |              |                |      |
| Processed milk                         | 0.519        |              |                |      |
| Margarine or butter                    | 0.492        |              |                |      |
| milk                                   | 0.431        |              |                |      |
| Sugar sweetened beverages              | 0.429        |              |                |      |
| sugar                                  | 0.412        | -0.358       |                |      |
| Instant noodles                        | 0.397        |              |                |      |
| Processed meat                         | 0.377        | -0.356       |                |      |
| Vegetables fried                       | 0.368        |              |                |      |
| Fried potatoes                         | 0.363        |              |                |      |
| Ready to eat meals                     |              | 0.535        | -0.341         |      |
| Tea or coffee                          | 0.404        | -0.534       |                |      |
| Vegetable cooked                       | 0.335        | -0.511       |                |      |
| Organ meat                             | 0.317        | 0.455        |                |      |
| meat                                   |              | 0.455        | -0.32          |      |
| Fried fish                             | 0.432        | 0.346        |                |      |
| chicken                                | 0.357        |              |                |      |
| fruit                                  |              | 0.336        |                |      |
| rice                                   |              |              |                |      |
| maize                                  |              |              | 0.524          |      |
| Salted dried fish                      | 0.333        |              | 0.501          |      |
| Commercial bread                       | 0.341        |              | -0.377         |      |
| Vegetables raw fresh                   |              |              | 0.332          |      |
| Diet beverages                         |              |              |                |      |
| Roots tubers                           |              |              |                |      |
| nuts                                   |              |              | 0.497          |      |
| fish                                   |              |              | 0.457          |      |
| Breakfast cereal                       | 0.337        |              | 0.387          |      |
| Fast food                              | 0.325        |              | -0.38          |      |
| legumes                                | 0.305        | 0.302        | 0.307          |      |
| Salty snacks                           |              |              | 0.307          |      |
Kaiser-Meyer-Olkin Measure of Sampling Adequacy 0.651, Bartlett's Test of Sphericity <0.001

Table 8. Partial correlation between body measures and PCA (RURAL)

| Variables         | Component 1  | Component 2              | Component 3              | Comp  |
|-------------------|--------------|--------------------------|--------------------------|-------|
|                   | Diverse diet | Vegetable convenience pattern | Non-convenience pattern |       |
| visceral fat      | 0.091(0.141) | -0.076(0.215)            | -0.091(0.139)            | 0.043 |
| body fat          | 0.823(0.183) | -0.111(0.072)            | -0.039(0.522)            | 0.061 |
| BMI               | 0.085(0.166) | -0.052(0.402)            | -0.088(0.152)            | 0.025 |
| waist circumference | 0.069(0.266) | 0.121(0.050)             | 0.023(0.715)             | 0.017 |

Controlled for age, gender and metabolic equivalent category

Table 9. Partial correlation between body measures and PCA (URBAN)

| Variables         | Component 1  | Component 2              | Component 3              | Comp  |
|-------------------|--------------|--------------------------|--------------------------|-------|
|                   | Diverse diet | Meat pattern             | Staple pattern           |       |
| visceral fat      | 0.077(0.308) | 0.092(0.222)             | -0.186(0.013)*           | -0.08t|
| body fat          | 0.844(0.266) | 0.019(0.799)             | -0.075(0.316)            | -0.12t|
| BMI               | 0.106(0.159) | 0.094(0.209)             | -0.163(0.029)*           | -0.10t|
| waist circumference | 0.078(0.297) | 0.037(0.626)             | -0.101(0.180)            | -0.02t|

Controlled for age, gender and metabolic equivalent category. *P-value <0.05

Table 10 shows a partial spearman correlation adjusted for age and gender between waist
circumference, BMI and body composition measures. All variables showed significant correlations but the strongest correlations were between visceral fat and BMI \( r=0.905(p<0.001) \), body fat and BMI \( r=0.851 \) (\( p<0.001 \)) and BMI and waist circumference \( r=0.845(p<0.001) \).

Table 10 Partial correlation between body composition, waist circumference and BMI.

| Control Variables | Variables | Visceral Fat r(p-value) | Body Fat r(p-value) | BMI r(p-value) | Waist r(p-value) |
|-------------------|-----------|-------------------------|---------------------|---------------|-----------------|
| Age in years, Gender | Visceral fat | 0.746(<0.001) | 0.905(<0.001) | 0.79 |
|                   | Body fat | 0.746(<0.001) | 0.851(<0.001) | 0.76 |
|                   | BMI | 0.905(<0.001) | 0.851(<0.001) | 0.84 |

Table 11 shows two models of multinomial logistic regression for risk factors of central obesity determined by waist circumference. Multicollinearity was checked and carbohydrate and fibre had strong correlations with energy intake and protein respectively and were therefore excluded from the model. In model 1 the obese group was set as reference for the outcome variable and urban and female were set as reference for the explanatory variables, community and gender respectively.

Metabolic equivalent category was added to model 1 to generate model 2. In model 1 males had about 22 times odds of being normal compared to females at \( p\)-value <0.001 while rural dwellers had odds of about 1.7 times of being normal compared to urban participants and this was significant at \( p<0.01 \). The predictability of gender for obesity persisted in model 2 but community showed no significant predictability.

Table 11. Multinomial logistic regression of predictors of obesity

| Model 1 | Model 2 |
|---------|---------|
| Waist circumference category | Explanatory variables | Odds ratios | Waist circumference category | Explanatory variables |
| Normal | Energy | 0.999(0.999-1.000)* | Normal | Energy |
|        | Protein | 1.008(0.997-1.019) |        | Protein |
|        | Fat | 0.996(0.987-1.005) |        | Fat |
|        | Sugar | 0.998(0.992-1.004) |        | Sugar |
|        | Community | |        | Community |
|        | Rural | 1.449(0.881-2.385) |        | Rural |
| Urban | | | Urban | |
| Gender | | Gender |
| Male | (9.72310.876-3944.)*** | Male |
| Female | Female |
| Overweight | Intercept | Metabolic category Not meeting WHO recommendation |
| Energy | 0.999(0.999-1.000)* | Meeting WHO recommendation |
| Protein | 1.004(0.994-1.016) | |
| Fat | 0.999(0.990-1.007) | Overweight | Intercept |
| Sugar | 1.001(0.995-1.008) | Energy |
| Community | Protein |
| Rural | 1.198(0.675-1.823) | Fat |
| Urban | Sugar |
| Gender | Community |
| Male | 1.991(0.790-5.018) | Rural |
| Female | Urban |

1. \( p<0.05, **p<0.01, ***p<0.001 \). aVariable set as reference. +Reference for weight category is obesity. Cox and Snell R-Squared is 0.243 and Naglekerke R-Squared is 0.277.

2. *\( p<0.05, **p<0.01, ***p<0.001 \). aVariable set as reference. +Reference for weight category is obesity. Cox and Snell R-Squared is 0.248 and Naglekerke R-Squared is 0.283.

Discussion
This study evaluated the association between nutrient consumption and body composition of rural and urban adults in Ghana. The study had a higher number of female participants compared to males and this is due to the fact that females were mostly encountered in the households during the period of this work. This finding is comparable to reports from the 2014 Ghana Demographic and Health survey [22].

The prevalence of overweight and obesity using BMI was 29.9% and 22.9% respectively with a total prevalence of 52.8%. The prevalence of overweight and obesity found in this study is comparable to what has been reported by some studies even though others have reported slightly higher or lower prevalence [22-25]. Several studies have reported a significantly higher prevalence of obesity by BMI among urban residents compared to rural residents but in this study, no significant difference was found [23, 26]. This implies that rural communities are gradually catching up with urban communities on the burden of obesity and therefore there is the need for further investigations and interventions to halt exponential positive BMI changes in rural settings. Bixby et al. reviewed population-based studies from 1985-2017 and they found that global increase in BMI and obesity is driven by increase in BMI among rural residents [27]. This finding together with findings from this study implies the need for an integrated approach to address the problem of malnutrition among rural residents. The problem of undernutrition which has been the focus over the years seems to give way to overnutrition driven by increased consumption of cheap caloric dense foods. The nutrition transition is no longer a phenomenon pertaining only to urban areas but to rural communities as well.

Total energy and carbohydrate intake were significantly higher among rural compared to urban participants. Though not statistically significant, sugar and saturated fat intake was higher among the urban sample. This finding supports the leading role cities play in the nutrition transition through higher availability and consumption of processed foods with corresponding low intakes of staple foods [28]. Additionally, multinomial logistic regression results from the study indicates that rural communities are associated with normal weight compared to urban centres. This finding was however not significant when metabolic equivalent category (physical activity) was included in the model. This finding also shows the importance of physical activity in the maintenance of weight irrespective of
geographical location and further buttresses the point that provision of environments that support healthy and balanced food consumption and physical activity has potential to reduce obesity in both rural and urban areas. Availability of sugary foods notably sugar-sweetened beverages in urban communities coupled with low levels of physical activity are associated with weight gain and risk of type 2 diabetes.

Central obesity determined by visceral fat was higher among urban participants. Central obesity is highly associated with cardiovascular diseases and poses a higher cardiometabolic risk compared to generalized obesity [18,19].

Prevalence of obesity determined by BMI, waist circumference and body fat were higher among females compared to males. Most studies have also reported a higher prevalence of obesity among women compared to men though most of these studies have only used BMI [29, 30]. BMI does not have gender specific cut offs. In this study where visceral fat, total body fat and waist circumference were used, all of which have gender specific cut offs, prevalence across all determinants was significantly higher for females compared to males. The only exception was for visceral fat which showed no significant difference.

Several factors put women at higher risk of obesity. Sedentary behavior such as long hours watching television and parity have been documented to cause weight gain in women [30]. Even though pregnancy and childbirth are associated with weight gain and retention it is possible for women to lose almost all the weight gained during pregnancy and childbirth [30, 31]. This can be achieved through education and interventions that empower women to avoid obesogenic behaviors post-partum which are thought to aid in lactation but are rather fattening. High occurrence of obesity among women is related to adverse pregnancy outcomes such as pre-mature delivery and low birth weight babies. Low birth weight is a risk factor for obesity in adulthood and this trend has led to developing countries experiencing a double burden of disease [32]. The prevalence of central obesity was also higher among females and this also puts them at risk of chronic non-communicable diseases. High amount of total body fat is associated with elevated blood pressure and this was higher among women compared to men [32]. Multinomial logistic regression also revealed that
female gender poses a significant risk to the development of obesity and this was irrespective of metabolic equivalent category. Cultural perceptions that link plumpness in women to beauty has been associated with the intake of corticosteroids among women as way to promote weight gain [33]. Several interventions have been tailored toward socio-economic empowerment of women in Ghana but findings from this study calls for more culturally sensitive interventions to be implemented to address the health challenges of women and also empower women toward taking charge of their health in order to achieve optimal health status.

The WHO recommends achieving minimum of 600 metabolic equivalents in a week which translates to 150 minutes of moderate intensity exercise or 75 minutes of vigorous intensity activity as a way to improve and maintain a healthy weight and cardiometabolic state. Approximately half of study participants majority of whom are females did not meet WHO recommendation for physical activity which translates to achieving a minimum of 600 metabolic equivalents per day. Participants not achieving this recommendation had a higher prevalence of obesity across all measures. There is the need for public education on the importance of physical activity in achieving and maintaining a healthy weight and cardio metabolic health.

Fat, protein, sugar and carbohydrate contribute to total energy intake and caloric intake positively associates with BMI. The intakes of the aforementioned nutrients were higher among obese participants and this was significant especially among rural residents. High caloric intake was associated with higher intakes of micronutrients but not with higher dietary diversity score. Principal component analysis revealed four different patterns for the two communities. For the urban community, pattern 3 showed an inverse significant relationship with visceral fat and BMI. Pattern 3 comprised of staple foods like maize, fried and salted fish and raw vegetables and low consumption of commercial bread, ready to eat meals and processed meat. Commercial bread, ready to eat meals and processed meat consumption are associated with increased body mass index and incidence of obesity while vegetable intake is associated with lower body mass index and in this study the protective effect persisted even after adjusting for age, gender and physical activity status [34]. This implies that an adaptation of a healthy diet pattern is instrumental in curbing the rise in obesity.
These findings support the call by the WHO for countries to provide a healthy food environment through the regulation of processed foods as means to halt the obesity pandemic. Among rural residents, none of the patterns generated significantly associated with any of the obesity measures. Waist circumference is a reliable tool for determining abdominal obesity. In this study it predicted the highest prevalence of overweight and obesity and this implies that BMI is often associated with the underestimation rather than the overestimation of adiposity among populations. Its strong positive correlation with other body composition measures supports the reliability of waist circumference as a measure of obesity and adiposity. This simple measurement can be used alone as a diagnostic tool to assess obesity and adiposity among populations and in clinical practice.

Conclusion
This study indicates shows that overweight and obesity continue to rise in Ghana, especially among females. Prevalence of obesity determined by BMI was similar among rural and urban dwellers. Interventions that regulate the food environment and makes affordable and available healthy food options such as vegetables are needed to control the rise in obesity rate and prevalence.

Limitation
This study was cross-sectional and hence conclusions about risk factors of obesity may be limited. The higher number of females compared to males is a limitation to this study and may have led to biases in the obesity and physical activity difference reported along gender lines.is also a limitation to this study.

Declarations
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Author contribution
Nana Ama Frimpomaa Agyapong, Reginald Adjetey Annan, Charles Apprey and Elizabeth Catherine Swart made substantial contribution to the conception and design of the study. Nana Ama Frimpomaa Agyapong, Charles Apprey and Linda Nana Esi Aduku made substantial contributions to data
collection and statistical analysis. Nana Ama Frimpomaa Agyapong and Reginald Adjetey Annan
drafted the manuscript. Elizabeth Catherinae Swart, and Charles Apprey and Linda Nana Esi Aduku
critically revised the manuscript. All authors have read and approved this final draft for submission.

Statement of competing interest
The authors declare no conflict of interest.

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