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Article

Associations Between Self-Perceived Psychosocial Stress and Markers of Adiposity in Ga Mashie, Urban Ghana: Evidence from a Cross-Sectional Population-Based Survey

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Academic Editor: Carmine Finelli

Received: 13 June 2025
Revised: 4 August 2025
Accepted: 6 August 2025
Published: 9 August 2025

Citation: Rougeaux, E.; Amon, S.; Baatiema, L.; Kushitor, S.B.; Kushitor, M.K.; Mensah, S.K.; Leiva-Granados, R.; Marphatia, A.A.; Wells, J.C.K.; Grijalva-Eternod, C.S.; et al. Associations Between Self-Perceived Psychosocial Stress and Markers of Adiposity in Ga Mashie, Urban Ghana: Evidence from a Cross-Sectional Population-Based Survey. *Obesities* **2025**, *5*, 60. https://doi.org/10.3390/obesities5030060

Abstract

Prior research from Ghana suggests psychosocial stress is associated with lower body mass index (BMI) and waist circumference (WC), both markers of adiposity, contrasting with meta-analyses showing positive associations in other settings. This study aimed to explore how stress was associated with markers of adiposity in urban Ghanaian adults. Data included 854 adults from the Contextual Awareness, Response and Evaluation Diabetes in Ghana survey carried out in November–December 2022 in Ga Mashie, a deprived area of the capital Accra. Associations between self-perceived stress (Perceived Stress Scale 10, categorized into low and average–high stress) and BMI or WC-for-height ratio (WHR) were assessed using linear regression. Results were adjusted for survey design and confounders and stratified by sex. Greater stress was associated with higher BMI and WHR in females (adjusted coeff. [95% CI]: BMI: 2.3 [0.5, 4.0], WHR: 0.03 [0.00, 0.06]). No associations were found in males. These findings highlight the need to understand the complex interactions between gender, stress, and increasing burdens of obesity and other associated non-communicable diseases in urban African settings, with a view to designing context-specific interventions to reduce risk.

Keywords: stress; obesity; deprivation; urbanization; Ghana

1. Introduction

Globally, 347 million males (14%) and 466 million females (18%) were living with obesity in 2020, more than half of whom were in low- and middle-income countries (LMICs) [1]. In Ghana, 50% of women and 21% of men aged 20–49 years were living with overweight or obesity in 2022 [1]. Trends show a steady incline over the past decades, and projections indicate current figures will likely increase by two- to three-fold in the coming decade [2,3]. Obesity tracks across the life course and may impact both current and future health as it has been associated with non-communicable diseases (NCDs) such as type 2 diabetes, cardiovascular disease (CVD), cancer, musculoskeletal disorders, and mental illness [4–7]. It may also negatively affect social outcomes and quality of life and have intergenerational impacts on wellbeing [8]. Furthermore, the health costs of obesity are recognized to be worse among those who experienced undernutrition (e.g., low birth weight, wasting, and stunting) in early life, an ongoing problem in many LMICs, including Ghana [9,10].

The rise in obesity and related NCDs can be broadly attributed to the nutrition transition and shift towards capitalist Western modes of food production and consumption, which have led to unhealthy diets high in fat and processed foods and more sedentary lifestyles [11]. Psychosocial stress (referred to as stress henceforth), defined as the psychological and physiological response to environmental challenges, may also be an important factor to consider. Stress has been associated with poorer health, including a higher likelihood of developing obesity [12–16]. Two meta-analyses found stress to be positively associated with markers of adiposity, including body mass index (BMI) and waist circumference (WC) [17,18].

Experiencing chronic stress is thought to increase the risk of obesity through pathways associated with increased cortisol, which stimulates appetite and the consumption of highly palatable foods and associated fat deposition [19–22]. Stress and increased cortisol have been found to increase abdominal (visceral) fat in particular [23]. It has been suggested that stressed individuals may eat more because of the pleasure-inducing and calming effect of food, particularly more calorie-dense and processed foods [24]. Stress can also lead to an increased risk of obesity through reduced physical activity and negative changes to sleeping habits [21,25].

Greater levels of urbanization have been associated with higher self-perceived stress, particularly in females [26]. Two studies from Germany also found that living in a place of greater urbanization, especially during early life (0–15 years), was associated with a more reactive physiological stress response system [27,28]. Greater noise and light pollution, often found in urban environments, and experiencing deprivation and difficult living and working conditions can all contribute to increased stress [29,30]. Females also often report greater stress than males, potentially due to differences in stress responsivity and social factors such as poverty, burdens of care, and intimate partner violence [31–33].

Ghana is one of the most urbanized countries in Sub-Saharan and West Africa, with 60% of its population living in urban areas [34]. More urbanized parts of Ghana bear a greater burden of obesity; data for adults in 2022 showed a prevalence of 22% in urban men and 11% in rural men, and 31% in urban women and 24% in rural women [1,35]. As in other LMICs, the rural–urban disparities have been largely driven by socio-economic differences [3,35,36]. At the same time, urban areas of Ghana have widespread informal housing, which are often characterized not only by overcrowding and precarious living conditions but also greater vulnerability to climatic events such as flooding and high levels of traffic congestion, all of which have been associated with greater levels of stress [37,38].

A study carried out in adults living in rural and urban areas of the Ashanti region, Ghana, found self-reported stress to be negatively associated with BMI and WC, in contrast to the two meta-analyses described previously, which found positive associations [17,18,39]. However, the meta-analyses included few studies from LMICs and none from Sub-Saharan Africa. This study, therefore, aimed to explore how stress was associated with markers of adiposity in adults living in Ga Mashie, a deprived area of the Ghanaian capital of Accra, and whether the differences varied by sex. Based on most of the existing literature, we hypothesized that increased stress would be associated with higher BMI and WC.

2. Materials and Methods

2.1. Study Design and Sample Collection

This is a cross-sectional study of data from the Contextual Awareness, Response and Evaluation (CARE): Diabetes in Ghana project survey carried out in the urban area of Ga Mashie in Accra, Ghana, between the 10th of November and the 8th of December 2022. Ga Mashie is made up of the communities of James Town and Ussher Town and is an area characterized by high deprivation and population density [40,41].

The CARE survey primarily aimed to estimate the prevalence and distribution of diabetes and NCD risk factors in adults in Ga Mashie [42]. A sample size of 1242 individuals was estimated based on an assumed diabetes prevalence of 5% and a precision and effect size of 2% and 2.5, respectively [43]. Based on assumptions regarding the average number of adults per household, household vacancy prevalence, and study refusal rates, it was estimated that 958 households would be needed to achieve this sample size.

Households were defined as a place of residence including one or more occupants who were not necessarily related but who shared the residential space and facilities. Only adults who were permanent residents (defined as living in the household for a year or more) and aged 25 years and over were deemed eligible. Females who were pregnant or had recently (in the past 6 months) given birth and individuals who were not capable of providing consent due to a mental or physical disability were excluded. All enumerators received training on ethics, data protection, and interview, anthropometric, and biological data collection procedures. A pilot study of 50 households was conducted to test these processes.

The 2021 local census was used as the sampling frame from which 80 enumeration areas were identified, and within which 12 households were to be selected by the Ghana Statistical Service using simple random sampling. This resulted in a sample of 959 eligible households (as only 11 households were selected for one of the enumeration areas).

Either household respondents or the head of their household provided household-level information on household structure and socio-economic characteristics during an initial household interview. Individual-level information was collected from study participants in an individual interview on their level of physical and mental health, quality of life, health-related habits and behaviors, household socio-economic circumstances, and characteristics. Physical measurements were also taken, including anthropometric (height, weight, and WC), diastolic and systolic blood pressure, and random blood glucose measurements. Both the interview and physical measurement data were collected by trained local fieldworkers. Further details on the study design and data collection processes can be found in the protocol [42].

Details of the surveyed sample obtained were provided in a previous publication [44], a summary of which is provided here. Of the 959 eligible households identified, 644 were surveyed (as 31% were not found and 1.5% refused to participate). Within these, 1007 individuals were eligible to be surveyed, of whom 13.5% were absent and 1.8% refused to participate, leading to a final surveyed sample of 854 individuals living across 629 households, with a response rate of 85%. Using data obtained during the household interview, we found that among individuals who were absent or refused to participate (n = 153), there was a greater share of males (20% of the eligible sample versus 12% for females), of individuals in the middle and top wealth tertiles (both at 17% versus 12% for the bottom tertile), and of younger individuals (20% aged 25–44 years versus 4% aged 65 years and over).

2.2. Measurements

2.2.1. Self-Perceived Stress

Stress was assessed using the 10-item Perceived Stress Scale (PSS-10), which has been validated in adults [45] and used in several African settings, including Ghana [46–49]. The PSS-10 assesses the degree to which the respondent's current situation may be perceived as stressful using 10 questions to capture recent negative and positive feelings and emotions [45]. For example, participants were asked if, in the last four weeks, they had been a very nervous person or if they had felt lively and energetic.

Responses were given using a Likert-type scale from 1 ("none of the time") to 5 ("all of the time"). Responses from positive questions were inverted to allow them to be combined with negative questions. The full questionnaire is provided in Appendix A. A Cronbach's alpha of 0.76 indicated adequate internal reliability [50]. There were no missing data for any of the questions. Responses from all questions were summed to create a score, with higher values indicating higher stress. This score was then categorized into low (scores of 0–13), moderate (scores of 14–26), and high (scores of 27–40) stress, as in other similar research [51]. Due to the low number of participants in the high-stress category, we chose to combine the moderate and high-stress categories for the regression analyses.

2.2.2. Outcomes

Two outcomes, BMI and WC, reflecting excess adiposity, were assessed. BMI has been used extensively in studies across different settings and populations to assess body mass whilst controlling for height. Categories of BMI were defined to reflect whether a person might be of a healthy weight, under- or overweight, as described further below [52]. BMI, however, has its limitations as it reflects both fat and lean mass and provides no information on fat distribution [53]. WC has been shown to be a good estimator of visceral fat, particularly after adjusting for height, and is more strongly associated with long-term health problems, such as hypertension and diabetes, compared to BMI [54,55]. Research suggests that having a WC less than half of one's height (i.e., a WC-to-height ratio [WHR] of less than 0.5) is associated with a lower risk of obesity and related disease compared to having a WC of half of one's height or more [56,57].

BMI

Height and weight were measured twice using a stadiometer (to the nearest 0.1 cm) and a digital scale (with a precision of 0.1 kg), respectively, as described in the protocol in [42]. For both, mean values of the two measurements were estimated. These were then used to calculate BMI (as weight/height^2), providing units of kg/m^2. For the descriptive analyses, BMI was further categorized into groups defined as underweight (BMI $\leq$ 18.5), healthy (BMI from 18.5 to <25), overweight (BMI from 25 to <30), and obesity (BMI of 30 or more) [52].

Waist Circumference

WC was measured twice using a tape measure, with a precision of 0.1 cm, and the mean value was estimated. Mean WC was divided by height to obtain WHR. This was chosen as our main WC outcome as it is comparable with other research and easily interpretable [58].

Additionally, for descriptive analyses, we created categories of WHR as follows: healthy (WHR < 0.5), high (WHR $\geq$ 0.5 but <0.67), and very high (WHR $\geq$ 0.67).

2.2.3. Covariates

Several covariates were identified that may have influenced both stress and adiposity based on associations found in previous studies of adults in Ghana [29–33,59–66]. These were based on information provided by the individual participant or household respondent and included the following:

- Age (in years)
- Sex (male/female)
- Marital status: categorized as married/cohabitating, divorced/separated, widowed, never married for the descriptive analyses, and as a binary measure, married/cohabitating, or other in the regression analyses.
- Wealth index score: created using Principal Component Analysis of assets owned [44], categorized into tertiles (referred to as bottom [most poor], middle, and top).
- Currently working: defined as being currently in paid/remunerative work or not
- Educational attainment: none/pre-school, primary, middle/junior high school, and secondary/senior high school/higher education.

2.3. Analyses

All analyses were conducted using Stata 17 [67]. The data were first explored to assess participant socio-demographic characteristics (reported as weighted percentages [95% confidence intervals (CIs)] and frequencies). Level of health was also assessed by estimating the prevalence of categories of BMI (healthy, overweight, or obesity), WHR (healthy, high, or very high), and self-perceived stress (low, moderate, or high) by sex. Chi2 tests were conducted to assess the associations of stress, BMI, and WHR with sex. Categories of BMI and WHR were also cross-tabulated for each sex in turn. Results are reported as weighted% and their 95% confidence intervals and *p*-values, where Chi2 tests were carried out.

Linear regression analyses were performed to assess the relationship between self-perceived stress category and continuous BMI and WHR, in turn, with results provided as coefficients, 95% CIs, and *p*-values. Covariates were identified as potential confounders if they were found to be associated with both stress and BMI/WHR using Chi2 or ANOVA tests and, based on reasoned assumption, not deemed to be on the causal pathway between stress and BMI/WHR. The regression analyses were stratified by sex. Additionally, to assess the magnitude of change in BMI/WHR associated with stress, predicted mean BMI and WHR and their 95% CIs were obtained from adjusted regression post-estimation Stata margins commands [67] and provided in graphical form. These are referred to as marginal predictions.

Participants with low BMI (<18.5) were excluded from the regression analyses as the focus of this paper was adiposity, and the inclusion of low BMI would have required more complex modeling. For comparison, regression analyses were nonetheless also carried out without excluding this group, and the results are briefly reported in the text.

All analyses took the survey design into account using Stata svy commands [67]. These considered both the clustered survey design and applied weights for individual-level analyses, which had been previously calculated as the ratio of the number of surveyed individuals to the number of individuals within each Census 2021 enumeration area. A robust variance estimator was applied, the default for svy analyses. No generative artificial intelligence was used in this study.

3. Results

3.1. Sample Characteristics

3.1.1. Socio-Demographic Characteristics

Of the 854 participants, the majority were females and participants below the age of 65 years (Table 1). Being married or cohabitating was the most common marital status. Most participants (80%) were considered non-migrant, i.e., they were born and had always lived in the community of Ga Mashie. Most participants (77%) reported being from the Ga-Dangme ethnic group. Approximately 30% were in the bottom (poorest) wealth tertile, over 70% were currently working, and more than half had an educational attainment greater than primary school.

Table 1. Socio-demographic characteristics of the CARE Ghana study sample (*N* = 854).

		Weighted % (95% CI)	*n*
Sex	Female	64 (60, 67)	549
	Male	36 (33, 40)	305
	Missing	-	0
Age	25–44 years	46 (42, 50)	395
	45–64 years	39 (35, 42)	327
	65+ years	15 (13, 18)	128
	Missing	-	4
Marital status	Married/ cohabitating	48 (44, 53)	409
	Divorced/separated	18 (15, 22)	158
	Widowed	15 (13, 18)	131
	Never married	18 (15, 22)	153
	No response/missing	-	3
Internal migration status	Non-migrant (always lived in Ga Mashie)	80 (76, 84)	679
	Urban migrant	15 (12, 19)	126
	Rural migrant	5 (3, 7)	41
	Missing	-	8
Ethnicity	Akan	13 (10, 16)	113
	Ga-Dangme	77 (73, 82)	654
	Other	10 (8, 12)	87
	Missing	-	0
Wealth tertiles (based on asset index)	Bottom (poorest)	33 (28, 39)	277
	Middle	32 (27, 38)	284
	Top (least poor)	35 (30, 40)	293
	Missing (*n*)	-	0
Currently working	No	27 (23, 31)	226
	Yes	73 (69, 77)	628
	Missing	-	0
Educational attainment	None/pre-school	13 (10, 16)	100
	Primary	19 (16, 23)	176
	Middle/junior high school	40 (37, 44)	343
	Secondary/senior high school/higher	28 (23, 33)	235
	Missing	-	0

% = percentage, *N*/*n* = number, CI = confidence interval.

There were some sex differences (reported in previous work), with females being more likely to be divorced, separated, or widowed, having lower levels of wealth, being less likely to report currently working, and having lower educational attainment [44].

3.1.2. Health Characteristics

Males had a mean BMI of 24.9 kg/m^2 (with a standard deviation of 4.9) and WHR of 0.5 (0.1), and females had a mean BMI of 29.9 kg/m^2 (7.2) and WHR of 0.6 (0.1). Table 2 presents the prevalence of BMI and WHR categories and self-perceived stress in males and females. When comparing females and males, we find that more females had obesity (defined by BMI) compared to males (46% (95% CI: 38, 54) versus 15% (10, 22) Chi2 test *p*-value < 0.0001) and very high WHR (25% (19, 32) versus 3% (1, 6); $p < 0.0001$). Though females also had higher stress than males, differences were small (among females, 78% (73, 83) had moderate stress and 2% (1, 5) had high stress versus 77% (71, 82) moderate stress and no high stress in males; $p = 0.0487$).

Table 2. Health characteristics in the CARE Ghana study sample ($N = 854$).

		Males % (95% CI)	Females % (95% CI)
Body mass index (BMI)	Underweight (BMI ≤18.5)	6 (3, 9)	2 (1, 5)
	Healthy (BMI > 18.5 & <25)	51 (44, 57)	23 (19, 28)
	Overweight (BMI ≥ 25 & <30)	30 (25, 36)	27 (23, 32)
	Obesity (BMI ≥ 30)	14 (10, 21)	47 (43, 52)
Chi^2 test *p*-value		<0.0001	
Waist circumference-to-height ratio (WHR)	Healthy (WHR < 0.5)	44 (38, 51)	14 (11, 18)
	High (WHR = 0.5 to <0.67)	53 (47, 60)	60 (55, 65)
	Very high (WHR ≥ 0.67)	3 (1, 6)	26 (21, 31)
Chi^2 test *p*-value		<0.0001	
Self-perceived stress	Low (PSS-10 score 0–13)	24 (19, 29)	19 (15, 25)
	Moderate (PSS-10 score 14–26)	77 (71, 82)	78 (73, 83)
	High (PSS-10 score 27–40)	0 (0, 0)	2 (1, 5)
Chi^2 test *p*-value		0.0487	

PSS-10 = Perceived Stress Scale 10, % = percentage, N/n = number CI = confidence interval. Missing (N): BMI 4, WHR 4, self-perceived stress 0.

The categorical BMI and WHR variables were also combined and tabulated for each sex in turn. This indicated that, compared to females, males had a higher prevalence of both healthy BMI and healthy WHR (34% (29, 40) versus 10% (7, 13) in females) and both overweight BMI and healthy WHR (4% (2, 8) versus 1% (0, 2) in females) but a lower prevalence of both obesity BMI and high WHR (11% (7, 16) versus 22% (18, 26)) and of both obesity BMI and very high WHR (2% (1, 6) versus 24% (20, 29)) (Appendix B Table A1).

3.2. Regression Results

After adjusting for potential confounders (age, education, work status, marital status, and wealth), compared to females with low stress, females with moderate–high stress had a BMI 2.3 kg/m^2 (95% CI: 0.5, 4.0) and a WHR 0.03 units (0.00, 0.06) higher (Table 3). In males, in contrast, the coefficients suggested that greater stress was associated with a lower BMI and WHR; however, there was no evidence to support any associations, as indicated by the confidence intervals (Table 3).

Figures 1 and 2 further illustrate the findings from the regression model shown in Table 3. These display marginal predictions of BMI and WHR obtained from regression postestimation. Like the regression results, these show that both BMI and WHR were higher in females with higher stress, while in males, there was little difference in BMI or WHR between different levels of stress.

Table 3. Linear regression of self-perceived stress and body mass index or waist circumference-to-height ratio stratified by sex in the Ghana CARE Diabetes study (*N* = 820).

		Body Mass Index			Waist Circumference-to-Height Ratio		
		Mean (SE)	**Unadjusted coeff. (95% CI); *p*-Value**	**Adjusted † Coeff. (95% CI); *p*-Value**	**Mean (SE)**	**Unadjusted Coeff. (95% CI); *p*-Value**	**Adjusted † coeff. (95% CI); *p*-Value**
Males							
Perceived Stress	Low	25.6 (0.7)	Ref.		0.53 (0.01)	Ref.	
	Moderate/high	25.3 (0.4)	−0.3 (−1.7, 1.2) $p = 0.742$	−0.2 (−1.6, 1.2) $p = 0.789$	0.52 (0.01)	−0.01 (−0.04, 0.01) $p = 0.291$	−0.02 (−0.04, 0.01) $p = 0.209$
Females							
Perceived Stress	Low	28.6 (0.7)	Ref.		0.59 (0.01)	Ref.	
	Moderate/high	30.6 (0.4)	2.1 (0.4, 3.7) $p = 0.018$	2.3 (0.5, 4.0) $p = 0.012$	0.61 (0.01)	0.02 (−0.01, 0.05) $p = 0.190$	0.03 (0.00, 0.06) $p = 0.050$

† Adjusted for age, education, work status, marital status, and wealth; coeff. = coefficient; CI = confidence interval; SE = standard error.

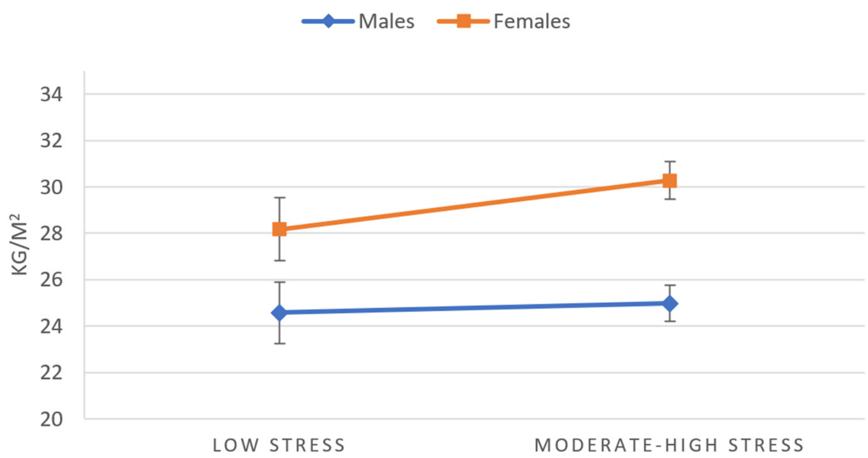

Figure 1. Marginal predictions of body mass index by self-perceived stress and sex in the Ghana CARE study, obtained from the adjusted linear regression of self-perceived stress and body mass index or waist circumference-to-height ratio by sex (*N* = 820).

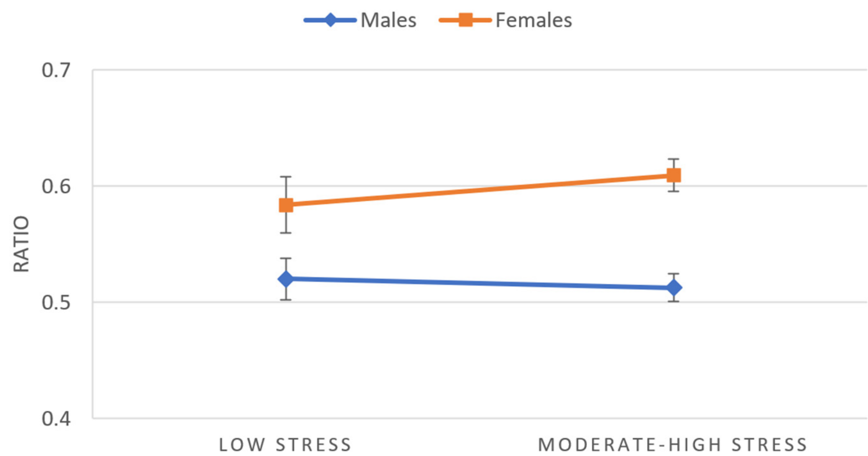

Figure 2. Marginal predictions of waist circumference-to-height ratio by self-perceived stress and sex in the Ghana CARE study, obtained from the adjusted linear regression of self-perceived stress and body mass index or waist circumference-to-height ratio by sex (*N* = 820).

In addition, the figures highlight the higher BMI and WHR observed in females compared to males, particularly when comparing females with moderate–high stress levels to males with any stress level.

4. Discussion

4.1. Summary of Findings

This analysis aimed to explore how stress was associated with markers of adiposity in Ghanaian adults living in Ga Mashie and whether the differences varied by sex and after adjusting for confounders. Based on existing international literature, we hypothesized that increased stress was associated with higher BMI and WC.

Two markers of adiposity were assessed: BMI (a proxy for total fat) and WHR (a proxy for visceral fat). We found that, in line with our hypothesis, higher self-perceived stress in females was associated with greater BMI and WHR. Findings in males contrasted with our hypothesis, however. Although males with greater stress had slightly higher BMI and lower WHR than less-stressed males, differences were smaller than in females, and associations were not statistically significant.

4.2. Comparison with Other Research

Compared to the most recent national data for urban adults, the prevalence of obesity was lower in males (14% versus 22% nationally) and higher in females (47% versus 31% nationally) [1]. This is in line with previous research using 2014 national data, which found that adult females in the Accra region had higher BMI than those in other urban regions [36]. It is not clear why males have a lower prevalence in our study compared to the national data; this may be due to differences in socio-economic and demographic sample characteristics.

Two meta-analyses from 2018–19 explored stress and various markers of excess weight gain and adiposity, including BMI, WC, triglycerides, and metabolic syndrome [17,18]. While Tenk et al. reported heterogeneous findings across individual studies included in their review, their meta-analysis showed an overall positive association between stress and both BMI and WC [17]. This was also found in both males and females, though the correlation was stronger for stress and WC in males than in females [17]. Similarly, in their meta-analysis, Kuo et al. found a positive association between stress and metabolic syndrome, defined as a cluster of metabolic abnormalities that includes abdominal obesity [18]. However, none of the studies included were from the Sub-Saharan region, and no comparisons were made by sex.

A cross-sectional study of 17 LMICs showed an overall positive association between self-reported work/home stress and obesity, but with significant heterogeneity across regions, and no countries from the African region were included [68]. Among studies conducted in African settings, one from the Republic of Seychelles showed similar findings to ours, with stress in social life positively associated with obesity in females but negatively in males [69]. In contrast, other research from Ghana discussed previously found self-reported stress at home/work to be associated with lower BMI and WC [39]. This study was, however, conducted in a different area (the Ashanti region) and included both rural and urban areas. To the best of our knowledge, no other studies have explored these associations in Ghana and specifically in urban areas; nonetheless, in a study conducted in another urban community of Accra, Ghana, stress was found to be associated with hypertension—a health problem often associated with obesity—and in females but not males [70,71].

Contrasting findings in the literature may also stem from different ways of assessing stress, with Baratin et al.'s measure consisting of only two questions specifically focused on home or work environments, whereas Chamik et al.'s study asked four questions about stress level in relation to work, social networks, finances, and living environment [39,69]. In their meta-analysis, Tenk et al. compared studies using measures of global stress and work-specific stress, finding stronger associations in the former [17]. In contrast, we used a validated and widely used measure of self-perceived stress that includes 10 different questions to capture the thoughts and behaviors that reflect different types of stress in everyday life.

4.3. Implications

As previously highlighted, excess adiposity, particularly in the abdominal region, may increase risks of NCDs [4–7]. The INTERHEART cross-country study, which included participants from nine African countries (though not Ghana), showed Black Africans to have 30% increased odds of myocardial infarction per 1 standard deviation (SD) or 4 kg/m^2 increase in BMI [72]. A meta-analysis by De Koning et al. also found that a 0.01-unit increase in WHR was associated with a 2–5% increased risk of CVD incidents [73]. In our study, this would suggest that females with moderate–high stress may have a 6–15% increased risk of developing CVD. De Koning et al.'s study did not, however, consider ethnicity nor include non-Western settings. A Lancet study of LMICs showed that an increase in BMI, regardless of baseline BMI, was associated with a higher prevalence of diabetes across all regions [74]. Though Ghana was not included in the study, data on females in Togo and Burkina Faso indicated a 5% increased risk of diabetes per increase of 1 kg/m^2 of BMI, which, in our study, would mean an increased risk of almost 20% for females who have moderate–high stress compared to those with low stress [74].

There may also be intergenerational consequences for wellbeing as both maternal stress and poor metabolic health can negatively impact child growth and long-term health [75–78]. Furthermore, if predisposed to subsequent rapid weight gain, early growth restriction in children could lead to the development of obesity later (though the evidence for this comes primarily from high-income settings thus far) [79,80]. Stress may have important implications for health in LMICs, where almost 80% of NCD deaths are thought to occur [81]. With both accelerating urbanization, increasing urban poverty, and the ongoing climate crisis, the burden of stress in LMICs will likely increase [34,82]. Our findings suggest that this may, in turn, further exacerbate the burden of obesity and related NCDs in these settings.

It is unclear why stress may be associated with higher BMI and WHR in females but not males. The findings could reflect different physiological pathways in dealing with stress in males than in females [31]. Studies have also suggested that males and females may have different experiences of stress and different behavioral responses or coping mechanisms in response to stress [83]. For example, females who have experienced stress have been found to be more likely to develop unhealthy patterns of alcohol consumption than males [84]. Other studies have additionally shown that females can be more susceptible to stress-induced eating than males [85]. However, descriptive findings of food habits (based on consumption the previous day) from other work on the CARE study do not appear to show any obvious differences by sex that could help explain our findings. Women and men generally had similar food habits, including foods that may be considered comfort foods (like baked sweets or fast food) [86]. The qualitative results did, however, highlight changes in the way food was consumed, with participants reporting less time, space, and/or money to cook at home compared to previous years, and therefore resorting to unhealthier and cheaper options like street food [86]. It is possible that males and females are affected by these changes in different ways. Females in Ghana have also been found to have lower levels of physical activity than males, which may be explained by different types of economic activities (like fishing versus tabletop trading), differences in time available, and/or desire for leisure physical activity among other factors [87,88]. As physical activity has been shown to reduce cortisol and help regulate appetite, this could help explain why stress in males was not associated with increased markers of adiposity [89,90]. The explanation may also lie in the measurement of adiposity, however. Further research exploring the relationship between food and sedentary behaviors by sex may help elucidate why stress and adiposity are associated in Ga Mashie. Sleep may be another pathway to explore, as it has been suggested to mediate the association between stress and metabolic health in other settings [91].

It is important to note that, like this study, much of the evidence on stress and obesity is cross-sectional. Research suggests that the relationship between stress and obesity may be bidirectional, as some studies have shown that obesity can also increase stress through physiological responses to obesity-related inflammation and/or as a response to the physical and social experience of living with obesity [19,21,92]. However, in their meta-analysis, Kuo et al. compared cross-sectional and longitudinal studies, finding similar associations across both [18]. This suggests that in our study, stress may indeed be associated with a greater BMI and WHR; regardless, stress remains a potentially important area for intervention, as studies have shown better success in weight loss when accompanied by stress reduction [93].

4.4. Strengths and Limitations

The main strengths of this research are the use of a contemporary study with a population-based sample representative of the area of Ga Mashie and a wide range of information collected, allowing us to (i) have objectively measured outcomes that include weight, height, and WC, enabling us to assess excess adiposity in different ways; (ii) have a validated and widely used measure of perceived stress; and (iii) adjust for confounders. Some limitations, however, warrant attention. First, the cross-sectional design limits our ability to make any inferences regarding the direction of the relationship between stress and obesity. Second, while the different levels of stress in males and females may reflect true differences, they may also be the result of measurement bias, whereby females perceived and/or reported stress differently than males. Thirdly, as discussed previously, there are limitations regarding the outcomes used. The first reason is that measures like BMI and WHR are proxy measures of body composition and reflect both lean and fat mass. The second reason is that these measures may reflect body composition differently across ethnicities. Notably, some studies have shown that, for the same BMI and WC, people from Black backgrounds had lower visceral fat than people from White backgrounds [94,95]. It is therefore also possible that we may have overestimated adiposity in our study. Finally, while the study design and statistical approach ensure that the results are representative of Ga Mashie, these may not be generalizable to other areas of Accra or Ghanaian cities.

5. Conclusions

Greater self-perceived stress was associated with an increase in proxy markers of total and visceral adiposity for females living in the urban area of Ga Mashie. No associations were found for males. Our findings highlight the need to understand the complex interactions between sex, stress, and increasing burdens of obesity and other associated NCDs in urban African settings, with a view to designing context-specific interventions to reduce risk. Interventions that reduce psychosocial stress may hold the potential to reduce the burden of obesity in adults in LMICs.

Author Contributions: Conceptualization, E.R.; methodology, E.R., M.K.K., R.L.-G., A.A.M., J.C.K.W., C.S.G.-E. and E.F.; formal analysis, E.R.; investigation, E.R., M.K.K., R.L.-G., A.A.M., J.C.K.W., C.S.G.-E. and E.F.; data curation, E.R. and C.S.G.-E.; writing—original draft preparation, E.R.; writing—review and editing, E.R., S.A., L.B., S.B.K., M.K.K., S.K.M., R.L.-G., A.A.M., J.C.K.W., C.S.G.-E., I.A.K. and E.F.; visualization, E.R.; supervision, E.F.; funding acquisition, E.F. All authors have read and agreed to the published version of the manuscript.

Funding: The project is supported by funds from the Medical Research Council (MRC) through United Kingdom Research and Innovation (UKRI), grant number MR/T029919/1. The funder had no role in the design and conduct of this study.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ghana Health Service (GHS-ERC: 017/02/22), the Noguchi Memorial Institute for Medical Research Institutional Review Board, University of Ghana (NMIMR-IRB CP 060/21–22), and the University College London Research Ethics Committee (ID: 21541/001). Further details on the study design and data collection processes can be found in the protocol.

Informed Consent Statement: Written informed consent was obtained from all participants.

Data Availability Statement: The data presented in this study are available on request from the corresponding author (the data are not currently publicly available due to ethical restrictions).

Acknowledgments: We are grateful to the Ghana Statistical Services, the Ga Mashie Development Authority, and the CARE Diabetes Team members for their support, and to the residents of Ga Mashie for providing their time and information for the CARE Diabetes study.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

BMI	Body Mass Index
WC	Waist circumference
WHR	Waist-to-height ratio
LMIC	Low- and middle-income countries
NCD	Non-communicable disease
CVD	Cardiovascular disease
CARE	Contextual Awareness, Response and Evaluation
PSS-10	10-item Perceived Stress Scale

Appendix A. PSS-10 Questionnaire

1. In the past four weeks, how often have you been upset because of something that happened unexpectedly?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
2. In the past four weeks, how often have you felt that you were unable to control the important things in your life?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
3. In the past four weeks, how often have you felt nervous and stressed?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often

4. In the past four weeks, how often have you felt confident about your ability to manage your personal problems?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
5. In the past four weeks, how often have you felt that things were going your way?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
6. In the past four weeks, how often have you found that you could not cope with all the things that you had to do?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
7. In the past four weeks, how often have you been able to control irritations in your life?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
8. In the past four weeks, how often have you felt that you were on top of things?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
9. In the past four weeks, how often have you been angered because of things that happened that were outside of your control?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often
10. In the past four weeks, how often have you felt difficulties were piling up so high that you could not overcome them?
    a. never
    b. almost never
    c. sometimes
    d. fairly often
    e. very often

Appendix B

Table A1. Cross tabulation of BMI and WHR categories by sex (N = 854).

	Males % (95% CI)	Females % (95% CI)
Underweight (BMI ≤ 18.5) & healthy WHR (WHR < 0.5)	5 (3, 8)	2 (1, 5)
Underweight & high WHR (WHR 0.5 to < 0.67)	1 (0, 4)	0 (0, 0)
Underweight & very high WHR (WHR ≥ 0.67)	0 (0, 0)	0 (0, 0)
Healthy BMI (BMI > 18.5 & <25) & healthy WHR	34 (29, 40)	10 (7, 13)
Healthy BMI & high WHR	16 (13, 21)	13 (10, 18)
Healthy BMI & very high WHR	0 (0, 0)	1 (0, 2)
Overweight & healthy WHR	4 (2, 8)	1 (0, 2)
Overweight & high WHR	25 20, 31)	25 (20, 30)
Overweight & very high WHR	<0 (0, 2)	1 (1, 3)
Obesity & healthy WHR	1 (0, 6)	1 (0, 4)
Obesity & high WHR	11 (7, 16)	22 (19, 26)
Obesity & very high WHR	2 (1, 6)	24 (20, 29)

% = percentage, N/n = number CI = confidence interval. Missing (n): BMI 4, WHR 4.

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