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ORIGINAL RESEARCH

Dietary Patterns, Nutrient Intakes and Metabolic Conditions Among Agro-Pastoralists in Monduli District, Tanzania

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Background: Unhealthy dietary patterns have contributed to the increase in metabolic syndromes in Tanzania. This study aimed to examine dietary patterns, nutrient intakes and investigate the association with obesity and high blood pressure among adults in agro-pastoral communities in Monduli district, Tanzania.

Methods: We conducted a cross-sectional study involving 283 adults aged from 18 years old. Blood pressure and anthropometry were measured from each participant. Dietary intake was assessed using a validated food frequency questionnaire. Principal component analysis was used to identify types of dietary patterns. Logistic regression model was used to examine the associations.

Results: Three types of dietary patterns were identified labeled as maize, beans and dairy; meat based; and fruits and vegetables. Higher intake of carbohydrates was found in maize dietary pattern. Meat dietary pattern was associated with higher intake of calcium and protein. Higher intakes of fiber and vitamin B2 was found in the fruits and vegetables dietary pattern. Participants on the third quartile of the maize pattern had higher odds of abdominal obesity (AOR=2.81; 95% CI: 1.09–7.26). Participants in the third and fourth quartiles of meat based pattern had increased odds of abdominal obesity by five (AOR=5.03; 95% CI: 2.31–10) and three folds (AOR=3.07; 95% CI: 1.36–6.92). Participants in the third quartile of fruits and vegetables dietary pattern have lower odds of general obesity (AOR = 0.25, 95% CI: 0.07, 0.9) and abdominal obesity (AOR = 0.25, 95% CI: 0.09, 0.71). No association between dietary patterns and high blood pressure was observed.

Conclusion: Three dietary patterns were identified in agro-pastoral communities. This study suggests that higher adherence to maize, beans and dairy dietary pattern and meat based dietary pattern may increase the risk of general and abdominal obesity. The fruits and vegetables dietary pattern may prevent from obesity. Further investigation is recommended to guide the preventive nutrition interventions.

Keywords: dietary pattern, obesity, high blood pressure, maize, dairy, red meat, vegetables, pastoral

Background

Obesity and metabolic conditions are associated with many non-communicable diseases (NCDs) such as cardiovascular diseases, type 2 diabetes and cancer.[1] These conditions are associated with poor quality of life, disability and mortality. They also increase the cost of the health care system significantly. Nowadays, most of the low and middle income countries (LMICs) are affected by rapidly increasing prevalence of these conditions.[2] These including the rising prevalence of high blood pressure and obesity which are the main risk factors for cardiovascular diseases such as heart diseases and stroke worldwide.[3] Globally, it was estimated that a quarter of the world's adults population had high blood pressure in 2002, and the prevalence will increase to 29% by 2025.[4] Tanzania is one of several African countries facing increasing rates of NCDs. The prevalence of obesity and other metabolic syndromes in the country has

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dramatically increased in the past decade.[5] More studies are therefore needed to inform public health actions to prevent these conditions and eventually to reduce the NCDs.

Poor dietary habits play an important role in the development of metabolic conditions such as obesity and high blood pressure. Studies that examined this relationship are very scarce among indigenous population of Africa, especially those living in poor resource settings such as in pastoral and agro-pastoral communities. Monduli District is one of five districts of Arusha region, Northern Eastern Tanzania. It is occupied mostly by the "Maasai" communities whose main livelihood is pastoralism. They are deep attached to their livestock and undertake minimal crop production mainly on maize which is low in micronutrients. In general, this could lead to cases of under-nutrition and the diets consumed being relatively low in diversity and thus lack essential micronutrients.[6] The food intake is mainly from grains and maize as staple foods. Meat products are rarely consumed, where animals are slaughtered for specific occasions or social obligations. Most of the milk, which is one of the most common animal products available among the community, is transported and sold to other neighboring areas. On the other hand, previous cross-sectional studies showed that 27% of adults had high blood pressure and 20.2% of them were obese in this district.[7,8] We therefore sought to identify the dietary patterns which may be potential dietary factor to prevent the rise of metabolic conditions. Dietary pattern reflects a combination of foods and may be easier to interpret and translate by the general public, potentially improving the development of and adherence to food-based dietary guidelines and recommendations.[9] This analysis has emerged as an alternative approach to examining the relationship between diet and the risk of metabolic syndromes.[10]

Very few studies regarding dietary patterns have been conducted in Tanzania.[11–16] For example, Katalambula et al[11] examined the dietary patterns that are associated with high blood pressure among adults in Arusha city in Tanzania. In addition, Keding et al[12] described and characterized the dietary patterns of rural women in three districts from north-eastern and central Tanzania. Moreover, other researchers have explored the association of dietary patterns with various clinical and health outcomes in different part of the country.[13,14,17] None of these studies, to our knowledge, assessed the relationship between dietary patterns and metabolic health of agro-pastoralists in Tanzania. Examination of the types of dietary patterns is very important to provide specific dietary recommendations to inform tailored interventions. Therefore, we evaluated the types of dietary patterns existed in agro-pastoral areas in the Monduli district. We also determine the associations between dietary patterns and some selected metabolic conditions which are high blood pressure, general obesity and abdominal obesity.

Materials and Methods

Study Population

This study involves adults 18 years of age or older residing in Monduli district in northern part of Tanzania. The participants were permanent residents in previously sampled villages in the district. Five (5) villages were selected randomly in the district as explained previously.[7] Briefly, participants were recruited in their traditional homesteads known as "bomas". We obtained the list of bomas in each village and selected them randomly. Usually, one boma may contain up to 10 households. A total of 15 bomas were selected from previously sampled villages. In each "boma" all adults were invited to participate until the required number is reached. With the help of research assistants, all participants were interviewed based on the interviewer-administered questionnaires and completed mandatory measurements.

Dietary Assessment

Food consumption data were collected by using a quantitative food frequency questionnaire (FFQ). The FFQ contained 27 food items featuring typical food items consumed in the community. We earlier examined the validity of this food frequency questionnaire (FFQ) and found that it can be useful in diet related disease studies.[18] All participants were required to indicate how many times they consumed each food item in the past month. The frequency of consumption was measured by selecting one of the following nine options: (1) never; (2) 1–3 per month (3) once per week; (4) 2–4 times per week; (5) 5–6 times per week; (6) once per day; (7) 2–3 times per day (8) 4–5 times per day (9) 6+ times per day.[19]

Dietary Pattern and Nutrients

In this study, the number of foods used to derive the dietary patterns was 25 by excluding some foods with consumption of less than 10% of participants due to lack of their variation. The quantity of food intake in g/day was calculated for each participant and was used to determine the dietary pattern. Dietary patterns were derived from factor analysis using principal component analysis (PCA). The number of patterns were selected based on the Scree plot and Eigenvalues of more than 1 using orthogonal transformed with varimax options.[20] The factor scores for each pattern was calculated and assigned to each participant. Main dietary patterns were labeled based on the highly loaded food items for each factor.[20] Food items with factor loadings less than 0.3 were disregarded for defining the dietary patterns.[13] The factor scores of each participants were then categorized into quartiles for analysis. For each participant, the factor scores indicated the extent to which his/her diet conformed to the respective dietary patterns.[11] Furthermore, nutrient values for each food were taken from the Tanzania Food Composition Table (TFCT).[21] The TFCT provides the amounts of each nutrient per 100 grams for individual foods, beverages and for mixed dishes.

Anthropometric Measurements

Weight and height were taken using a digital weighing machine, and a non-stretchable measuring tape, respectively. Body weight was measured to the nearest 0.1 kg precision. Height was measured using a measuring tape fixed on a height board to the nearest 0.1 cm precision. Participants were asked to remove shoes and heavy clothes before weight and height were measured. All anthropometric measurements were repeated at least two times for accuracy. Body mass index (BMI) was calculated as weight (kilograms) divided by squared height (meters) and then categorized as < 18.5 kg/m^2 as underweight, 18.5–25 kg/m^2 as normal, 25–30 kg/m^2 as overweight, and above 30 kg/m^2 as obesity. Waist circumference was measured at the thinnest point of the abdomen at the end of a normal expiration. Hip circumference was measured at the maximum circumference over the buttock horizontally. Both waist and hip circumferences were measured using a measuring tape with 1 mm accuracy. Waist-hip ratio (WHR) was calculated by dividing the waist by the hip circumference. Abdominal obesity was defined based on the WHO cut-offs, whereby measurement of WHR ≥0.90 in males and WHR ≥0.85 in females indicates higher risk for cardiovascular diseases.[22] Abdominal obesity by WC was determined by using a cut-off point of ≥ 102 cm for males and ≥ 88 cm for females.[22]

Measurement of Blood Pressure

Blood pressure was measured at least three times by trained health professionals. The participants rested for few minutes before their blood pressure was measured. All three measurements were performed in a sitting position for at least five minutes apart. The average of last two readings was used for analysis. Blood pressure was measured using a validated digital automatic blood pressure machine. Both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured. High blood pressure was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg.[23]

Statistical Analysis

Characteristics of all participants including demographic and anthropometric measurements were described by using means and standard deviations. Normality of data was checked using Kolmogorov–Smirnov test. The associations of dietary patterns quartile score with high blood pressure and obesity measures were evaluated by means of adjusted odds ratio (AOR) from multivariable logistic regression models, with quartiles of dietary patterns' scores as independent variables. The Statistical Package for the Social Sciences (version 23) was used for all analysis, and a *p*-value of <0.05 was considered significant.

Results

Dietary Patterns of the Study Population

A total of 283 participants were recruited in the study, of whom 181 (63.9%) were females and 102 (36.1%) were males. Their mean BMI was 32.5 (31.7). About 21% had high blood pressure, 24% general obesity, 35% abdominal obesity by WHR and 31% abdominal obesity by WC (Table 1). Three major components or dietary patterns were extracted from

Table 1 Demographic, Blood Pressure and Anthropometric Measures of the Study Participants (N=283)

Characteristics	Mean±SD or n (%)
Age (years)	36.4(17.1)
Gender	
Male	102(36.1)
Female	181(63.9)
Weight (kg)	59.8±12.7
Height (cm)	154.3±29.8
Body mass Index (BMI)	32.5±31.7
Waist circumference (cm)	90.5±28.1
Hip circumference (cm)	101.1±25.9
Systolic Blood Pressure (SBP)	104±29.3
Diastolic Blood Pressure (DBP)	63.4±18.7
Metabolic components	
Body mass index (BMI)	
Normal	158(56)
Overweight	58(20)
Obesity[a]	67(24)
Waist circumference (WC)	
Normal	195(69)
Obesity[b]	88(31)
Waist-hip ratio (WHR)	
Normal	185(65)
Obesity[c]	98(35)
Blood pressure	
Normal	224(79)
High blood pressure[d]	59(21)

Notes: [a]Based on criteria of BMI ≥30 kg/m^{2,} [b]Based on criteria of WC≥102 cm in males and ≥88 cm in females, [c]Based on criteria of WHR≥0.90 in males and ≥0.85 in females, [d]Based on criteria of SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg.

principal component analysis (PCA). The data met all statistical assumptions for carrying factor analysis: Bartlett's test of Sphericity confirmed that our data showed a patterned relationship among variables (p<0.001); Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA) was 0.689 which is greater than the recommended minimum value of 0.5.

Three dietary patterns were retained as suggested by the scree plot and Eigenvalues. The rotated components accounted for total variance of 74.6% of the food intake. The first dietary pattern is characterized by traditional foods consumed frequently in the community including porridge, maize stiff porridge, beans, milk, yoghurt and tea, we called this as "Maize, beans and dairy" explained 35.8% of the total variance. Pattern two was highly loaded by animal sourced foods such as beef and goat, we called this as "Meat based" accounted for 25.3% of the variance. The third dietary pattern accounted for 13.5% of variance characterized by high consumption of fruits and vegetables, and therefore we called this as "Fruits and Vegetables" (Table 2).

Nutrient Intakes

The association of each dietary pattern with energy-adjusted nutrient intakes are illustrated in Table 3. The maize, beans and dairy dietary pattern was associated with higher intake of Iron, vitamin C, vitamin B6 and vitamin B12. The meat based dietary pattern was associated with higher intake of calcium and protein (p<0.001). Significantly higher intakes of protein, fiber and Vitamin B2 were found in the fruits and vegetables dietary pattern. Furthermore, the mean percentage of energy (% energy) from carbohydrates was higher in maize, beans and dairy dietary pattern. Percentage of energy

Table 2 Factor Loading Scores of the Types of Dietary Patterns Derived in Study Population (N=283)

Food Items	Dietary Patterns		
	Maize, Beans and Dairy	**Meat Based**	**Fruits and Vegetables**
Mixed porridge	0.4021	–	–
Stiff porridge	0.4373	–	–
Maize with beans	0.8018	–	–
Beans alone	0.8341	–	–
Milk	0.6065	–	–
Yoghurt	0.7939	–	–
Maize with milk	0.4708	–	–
Tea with sugar	0.6744	–	–
Beef	–	0.9494	–
Goat meat	–	0.9179	–
Meat soup	–	0.7972	–
Banana with meat	–	0.3815	–
Fruit juice	–	–	0.654
Mangoes	–	–	0.490
Spinach	–	–	0.654
Cabbages	–	–	0.311
Carbonated beverages	–	–	–
Cassava	–	–	–
Sweet potatoes	–	–	–
Banana ripe	–	–	–
Vegetables mixed	–	–	–
Local brew	–	–	–
Milk tea with sugar	–	–	–
Green peas	–		–
Other green vegetables	–	–	–
Variance explained (%)	**35.8**	**25.3**	**13.5**
Eigenvalues	**4.1**	**2.5**	**1.1**

from fat and protein were higher in fruits and vegetables dietary patterns and meat patterns compared to maize, beans and dairy dietary patterns.

Association of Dietary Patterns and Metabolic Conditions

Table 4 reports the adjusted odds ratio (AOR) from multivariable logistic regression analysis after controlling for age, gender and energy intake of the participants. The analysis shows that participants in the third quartile (Q3) of maize pattern had higher odds of having abdominal obesity measured by WC (AOR=2.81; 95% CI: 1.09–7.26) compared to first quartile (Q1). Moving from first quartile (Q1) to fourth quartile (Q4) of the maize pattern score decreased the prevalence of high blood pressure (*P*-trend=0.019) and general obesity (*P*-trend=0.002), however, the odds of individual quartile were not significant. Similarly, participants in the third quartile (Q3) of meat pattern have increased odds of having abdominal obesity by WHR (AOR=5.03; 95% CI: 2.31–10.9). The analysis also found that participants in the third quartile (Q3) of fruits and vegetables dietary pattern have lower odds of general obesity (AOR = 0.25, 95% CI: 0.07, 0.9) and abdominal obesity by WC (AOR = 0.25, 95% CI: 0.09, 0.71). The odds of high blood pressure were not significant for all types of dietary pattern as shown.

Discussion

This study sought to identify dietary patterns among adults in agro-pastoral communities and examine whether these patterns were associated with some selected metabolic outcomes of high blood pressure and obesity. We derived three types of dietary patterns named as (1) maize, beans and dairy; (2) meat based; and (3) fruits and vegetables. Our findings suggest that the observed dietary patterns contributed to the development general and abdominal obesity in this

Table 3 Nutrients Intake According to types of Dietary Patterns Among the Study Participants (N=283)

Nutrients	Mean (SD)			*P*-value
	Maize, Beans and Dairy	Meat Based	Fruits and Vegetables	
Macronutrients				
Carbohydrates (g/d)	383.9(27.9)	381.8(25.5)	374.2(37.7)	0.102
Fat (g/d)	79.3(9.9)	79.1(10.5)	81.7(15.3)	0.317
Protein (g/d)	80.7(9.1)	82.5(10.8)	84.8(11.3)	0.036
Cholesterol (g/d)	79.2(34.3)	76.6(24.6)	78.1(34.4)	0.833
Fiber (g/d)	50.5(4.5)	51.9(7.3)	52.9(6.4)	0.029
Carbohydrates (% of energy)	62.9(5.4)	62.1(4.4)	58.8(3.2)	<0.001
Fat (% of energy)	27.6(4.4)	27.7(4.1)	30.1(2.8)	<0.001
Protein (% of energy)	12.4(1.5)	12.8(1.6)	13.8(1.2)	<0.001
Micronutrients				
Calcium (mg/d)	715.6(243.9)	848.3(228.9)	830.7(304)	<0.001
Phosphorous (mg/d)	1916.3(284.8)	1936.3(153.7)	1936.1(442.5)	0.854
Magnessium (mg/d)	614.1(36.3)	623.1(24.7)	610.5(58.7)	0.096
Potassium (mg/d)	3964.1(436.5)	3972.8(491.9)	3950.5(643.6)	0.963
Sodium (mg/d)	890.3(307)	817.4(229)	838.4(393.7)	0.195
Iron (mg/d)	22.5(1.75)	22.8(2.43)	23.2(2.12)	0.059
Zinc (mg/d)	11.5(0.7)	11.1(0.9)	11.4(0.7)	<0.001
Vitamin A (µg RE/d)	863.6(557)	764.9(322)	779.5(666.3)	0.325
Vitamin E (µg/d)	9.42(4.12)	9.15(6.8)	7.9(8.6)	0.299
Vitamin C (mg/d)	84.5(38.3)	73.3(26.1)	73.5(41.9)	0.035
Vitamin B2 (mg/d)	2.0(0.29)	2.1(0.24)	2.1(0.28)	0.009
Vitamin B6 (mg/d)	2.0(0.3)	1.8(0.2)	1.8(0.5)	<0.001
Vitamin B12 (µg/d)	2.3(0.4)	2.2(0.2)	2.1(0.5)	<0.001

Notes: All nutrients values were adjusted for total energy intake using residual method, If *P*-value <0.05 is significant, and <0.001 is highly significant.

community. We found that adherence to maize and meat based dietary patterns was associated with increased risk of obesity. In contrast, fruits and vegetables dietary pattern was associated with reduced risk of obesity. This study did not find the relationship between dietary patterns and the risk of high blood pressure. These findings were evident even after the control of effect of age, gender and total energy intake.

In comparison, the dietary patterns derived in this community showed some similarities with previous studies conducted among adults in rural and urban areas in Tanzania. The maize dietary pattern derived here is similar to the "traditional-inland" pattern identified by Keding et al,[12] and the "complex carbohydrate" pattern identified by Katalambula et al.[11] Although the maize pattern derived in this study is characterized by higher loadings of milk and dairy products, which is different with those reported in other studies in Tanzania. This could be due to ethnic differences as "Maasai" populations preferred milk and dairy products in their diet.[24] However, the reliance of milk in the traditional diet of pastoralists have been reduced over the years, and nowadays they are found to adhere to maize staples.[15] The second dietary pattern in this study contained meat products which accounted for 25.8% of the total variance of foods. Meat consumption is one of the key characteristic of the previously called "Western" dietary pattern as reported in other studies.[25] Similarly, meat and meat products dietary pattern was previously reported in rural households in Kilosa district.[13] Furthermore, we identified another dietary pattern dominated by fruits and vegetables food items. This was similar to "healthy" pattern identified by Katalambula et al,[11] and "Mchicha diet" pattern reported by Jordan et al.[14]

In general, this study suggests that the derived dietary patterns might have significant contribution to the development of metabolic conditions in agro-pastoral communities. We found a significant positive association between maize dietary pattern with obesity. The maize dietary pattern in this study is rich in beans, dairy products and many of carbohydrates rich foods such as maize meal and porridge. Similarly, Yu et al[26] and Zhang et al[27] have both reported that dietary patterns dominated by carbohydrates rich foods were associated with higher odds of obesity among adults and

Table 4 Association of Dietary Patterns Quartile Scores with Metabolic Conditions in Agro-Pastoral Communities (N=283)

Variables	Maize, Beans and Dairy				
	Q1	Q2	Q3	Q4	
		AOR (95% CI)	**AOR (95% CI)**	**AOR (95% CI)**	***P*-trend**
General obesity (BMI)	Ref	0.78(0.23–2.60)	2.41(0.90–6.74)	0.32(0.05–2.04)	0.002
Abdominal obesity (WC)	Ref	1.59(0.59–4.28)	2.81(1.09–7.26)*	0.30(0.04–1.87)	0.008
Abdominal obesity (WHR)	Ref	0.97(0.48–1.96)	0.82(0.41–1.67)	0.64(0.16–2.45)	0.704
High blood pressure	Ref	0.75(0.23–2.37)	0.33(0.08–1.38)	0.98(0.02–37.09)	0.019
	Meat Based				
		AOR (95% CI)	**AOR (95% CI)**	**AOR (95% CI)**	***P*-trend**
General obesity (BMI)	Ref	1.52(0.53–4.33)	1.15(0.38–3.48)	2.51(0.89–7.06)	0.017
Abdominal obesity (WC)	Ref	2.09(0.83–5.27)	2.56(1.01–6.53)*	1.35(0.51–3.53)	0.468
Abdominal obesity (WHR)	Ref	3.12(1.43–6.77)**	5.03(2.31–10.94)***	3.07(1.36–6.92)**	0.008
High blood pressure	Ref	0.51(0.09–2.86)	0.87(0.26–2.84)	0.81(0.17–3.75)	0.264
	Fruits and Vegetables				
		AOR (95% CI)	**AOR (95% CI)**	**AOR (95% CI)**	***P*-trend**
General obesity (BMI)	Ref	1.09(0.42–2.78)	0.26(0.07–0.90)*	0.68(0.22–2.09)	0.623
Abdominal obesity (WC)	Ref	0.84(0.35–1.99)	0.25(0.09–0.71)**	0.35(0.12–0.98)	0.205
Abdominal obesity (WHR)	Ref	0.81(0.39–1.65)	0.83(0.38–1.81)	0.60(0.27–1.32)	0.513
High blood pressure	Ref	1.10(0.27–4.51)	2.78(0.61–12.6)	3.93(0.88–17.4)	0.423

Notes: Significant at *P ≤ 0.05, **P<0.01, ***P<0.001 (2-tailed), If *P*-trend <0.05 is significant, and <0.001 highly significant, All models were adjusted for age, gender and energy intake.
Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; Ref, reference quartile.

adolescents in China. In Tanzania, a study found positive association dietary pattern characterized by bread, black tea and cakes on BMI among women aged 16 to 45 years.[12] Therefore, a positive association between this dietary pattern and the risk of obesity was expected due to high kilocalories and nutrient content from these foods. Nutrients analysis shows that participants adhere to this pattern have higher percentage of energy from carbohydrates than other patterns. Foods that have high amount of sugars in this pattern contributed to higher energy intake such as black tea.

This study indicates that there may be negative health consequences in adherence to meat dietary pattern on obesity. This is consistent with a body of literature conducted in different countries.[25,28] The increased risk of obesity with high meat consumption seen in this study might be related to high fat and added salt or simply that regular meat consumption is an indication of wealth in this community.[6] Moreover, vegetables dietary pattern appeared to be a protective factor for obesity. Similarly, a study done by Haidari et al in West Indian reported similar findings.[29] Previous studies found that fruits and vegetables dietary pattern are inversely related to body weight, waist-to-hip ratio and other metabolic conditions.[30] A protective effect from fruits and vegetables is probably due to higher intake of dietary fiber which can reduce glycemia from lower absorption and digestion of carbohydrates. However, in this study, vegetables dietary pattern is limited by higher intake of fats which may have counteracted the benefits that this pattern may had on obesity and blood pressure. Higher intake of fats from fruits and vegetables dietary pattern can be partly explained by cooking methods. Most of the participants prepared their vegetables by mixing with cooking oils. Therefore, vegetable intake may be acting as a marker for fats intake in this community.

The association between dietary patterns and high blood pressure was not significant in this study. Although the prevalence of high blood pressure decreased significantly across the maize pattern scores. Perhaps higher loadings of milk and dairy products in this pattern contributed to lowering the blood pressure levels. Previous body of literature showed that milk and dairy products is very important in the prevention of cardiovascular disease and lowering of blood pressure.[31–33] Diverse studies also showed suggestive evidence that dietary pattern dominated by milk and dairy products may reduce the risk of high blood pressure.[34,35] In addition, meat pattern was not found to contribute to risk of high blood pressure. This finding was not surprising as it was previously found that red meat consumption was not associated with hypertension among adults in Ngorongoro district in Tanzania.[36] Therefore, the association between dietary patterns and the risk of high blood pressure remains uncertain in this study population. Further longitudinal studies would be needed to understand the relationship between dietary factors and high blood pressure.

The strength of this study including the use of a validated food frequency questionnaire (FFQ) to determine the dietary patterns. The dietary patterns derived in this study were data-driven, which derived more reproducible and interpretable results than other types of dietary patterns. There are some important limitations in this study. First, this study was cross-sectional in nature, thus the causal relationship between dietary patterns and metabolic conditions could not be established. Second, the FFQ can give the reliable information on habitual consumption of foods, but the recall bias could not be avoided. Although we made efforts to control for confounders in this study, the effect of residual confounding could not be eliminated. Example, there may have been a healthy-adherer effect in people who adhered to a healthier diet. Such confounding factor was not measured in this study.

Conclusion

This study found three major types of dietary patterns among adults in agro-pastoral communities named as maize, beans and dairy; meat based and; fruits and vegetables. The traditional maize dietary pattern dominated maize, beans and dairy products was associated with increased risk of obesity. Higher adherence to meat based dietary pattern may increase the rise in prevalence of obesity. Only fruits and vegetables dietary pattern was found to protect against excess weight gain. This study did not show the association between dietary patterns and the risk of high blood pressure. However, the analysis suggests that there may be a negative association between maize, beans and dairy dietary pattern with high blood pressure, which needs to be confirmed in further studies. The findings may be used to guide the preventive nutrition interventions to curb the rise in obesity in Tanzania.

Abbreviations

BMI, body mass index; DBP, diastolic blood pressure; NCDs, non-communicable diseases; SBP, systolic blood pressure; WC, waist circumference; WHR, waist to hip ratio.

Data Sharing Statement

The data used to support the findings of this study are available from authors upon special request.

Ethical Approval and Consent to Participate

The study was conducted in line with the Declaration of Helsinki on health research. Written informed consent was obtained from all participants and from the village head. Ethical approval for the study was obtained from the Muhimbili University of Health and Allied Sciences (MUHAS). Permission to start the project was given by the Monduli district medical officer (DMO).

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Disclosure

The authors declare no conflicts of interest in this work.

References

1. World Health Organization. *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva: World Health Organization; 2009.
2. Ford ND, Patel SA, Narayan KM. Obesity in low- and middle-income countries: burden, drivers, and emerging challenges. *Annu Rev Public Health*. 2017;38(1):145–164. doi:10.1146/annurev-publhealth-031816-044604
3. Naghavi M, Forouzanfar MH. Burden of non-communicable diseases in sub-Saharan Africa in 1990 and 2010: global burden of diseases, injuries, and risk factors study 2010. *Lancet*. 2013;381:S95. doi:10.1016/S0140-6736(13)61349-5
4. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK. Global burden of hypertension: analysis of worldwide data. *Lancet*. 2005;4:365.
5. Mayige M, Kagaruki G, Ramaiya K, Swai A. Non communicable diseases in Tanzania: a call for urgent action. *Tanzan J Health Res*. 2011;13(5 Suppl 1):378–386. doi:10.4314/thrb.v13i5.7
6. Lawson DW, Borgerhoff Mulder M, Ghiselli ME, et al. Ethnicity and child health in northern Tanzania: Maasai pastoralists are disadvantaged compared to neighbouring ethnic groups. *PLoS One*. 2014;9(10):e110447. doi:10.1371/journal.pone.0110447
7. Khamis AG, Senkoro M, Mwanri AW, et al. Prevalence and determinants of hypertension among pastoralists in Monduli District, Arusha region in Tanzania: a cross-sectional study. *Arch Public Health*. 2020;78(1):99. doi:10.1186/s13690-020-00485-0
8. Khamis AG, Ntwenya JE, Senkoro M, et al. Association between dietary diversity with overweight and obesity: a cross-sectional study conducted among pastoralists in Monduli District in Tanzania. *PLoS One*. 2021;16(1):e0244813–e0244813. doi:10.1371/journal.pone.0244813
9. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol*. 2002;13(1):3–9. doi:10.1097/00041433-200202000-00002
10. Schulze MB, Martínez-González MA, Fung TT, Lichtenstein AH, Forouhi NG. Food based dietary patterns and chronic disease prevention. *BMJ*. 2018;361:k2396. doi:10.1136/bmj.k2396
11. Katalambula LK, Meyer DN, Ngoma T, et al. Dietary pattern and other lifestyle factors as potential contributors to hypertension prevalence in Arusha City, Tanzania: a population-based descriptive study. *BMC Public Health*. 2017;17(1):659. doi:10.1186/s12889-017-4679-8
12. Keding GB, Msuya JM, Maass BL, Krawinkel MB. Dietary patterns and nutritional health of women: the nutrition transition in rural Tanzania. *Food Nutr Bull*. 2011;32(3):218–226. doi:10.1177/156482651103200306
13. Ntwenya JE, Kinabo J, Msuya J, Mamiro P, Majili ZS. Dietary patterns and household food insecurity in rural populations of Kilosa District, Tanzania. *PLoS One*. 2015;10(5):e0126038. doi:10.1371/journal.pone.0126038
14. Jordan I, Hebestreit A, Swai B, Krawinkel MB. Dietary patterns and breast cancer risk among women in northern Tanzania: a case–control study. *Eur J Nutr*. 2013;52(3):905–915. doi:10.1007/s00394-012-0398-1
15. Hansen AW, Christensen DL, Larsson MW, et al. Dietary patterns, food and macronutrient intakes among adults in three ethnic groups in rural Kenya. *Public Health Nutr*. 2011;14(9):1671–1679. doi:10.1017/S1368980010003782
16. Bliznashka L, Danaei G, Fink G, Flax VL, Thakwalakwa C, Jaacks LM. Cross-country comparison of dietary patterns and overweight and obesity among adult women in urban Sub-Saharan Africa. *Public Health Nutr*. 2021;24(6):1393–1403. doi:10.1017/S1368980019005202
17. Sarfo J, Pawelzik E, Keding GB. Dietary patterns as characterized by food processing levels and their association with the health outcomes of rural women in East Africa. *Nutrients*. 2021;13(8):2866. doi:10.3390/nu13082866
18. Khamis AG, Mwanri AW, Ntwenya JE, et al. Design and validation of a food frequency questionnaire to assess the dietary intake for adults in pastoral settings in Northern Tanzania. *BMC Res Notes*. 2021;14(1):274. doi:10.1186/s13104-021-05692-8
19. Zack R, Irema K, Kazonda P, et al. Validity of an FFQ to measure nutrient and food intakes in Tanzania. *Public Health Nutr*. 2018;21:2211–2220. doi:10.1017/S1368980018000848
20. Chen Z, Liu L, Roebothan B, et al. Four major dietary patterns identified for a target-population of adults residing in Newfoundland and Labrador, Canada. *BMC Public Health*. 2015;15(1):69. doi:10.1186/s12889-015-1433-y
21. Lukmanji Z, Hertzmark E. Tanzania food composition tables; 2008.
22. World Health Organisation. Waist circumference and waist–hip ratio; Report of a WHO expert consultation. Geneva; 2008. Available from: https://www.who.int/nutrition/publications/obesity/WHO_report_waistcircumference_and_waisthip_ratio/en/visitedon15/03/2020. Accessed March 22, 2022.
23. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension*. 2003;42(6):1206–1252. doi:10.1161/01.HYP.0000107251.49515.c2
24. Mbalilaki JA, Masesa Z, Strømme SB, et al. Daily energy expenditure and cardiovascular risk in Masai, rural and urban Bantu Tanzanians. *Br J Sports Med*. 2010;44(2):121–126. doi:10.1136/bjsm.2007.044966
25. Naja F, Hwalla N, Itani L, Karam S, Sibai AM, Nasreddine L. A Western dietary pattern is associated with overweight and obesity in a national sample of Lebanese adolescents (13–19 years): a cross-sectional study. *Br J Nutr*. 2015;114(11):1909–1919. doi:10.1017/S0007114515003657
26. Yu C, Shi Z, Lv J, et al. Major dietary patterns in relation to general and central obesity among Chinese adults. *Nutrients*. 2015;7(7):5834–5849. doi:10.3390/nu7075253
27. Zhang Q, Chen X, Liu Z, Varma DS, Wan R. Dietary patterns in relation to general and central obesity among adults in Southwest China. *Int J Environ Res Public Health*. 2016;13:452.
28. Sun J, Buys NJ, Hills AP. Dietary pattern and its association with the prevalence of obesity, hypertension and other cardiovascular risk factors among Chinese older adults. *Int J Environ Res Public Health*. 2014;11:e43.
29. Haidari F, Shirbeigi E, Cheraghpour M, Mohammadshahi M. Association of dietary patterns with body mass index, waist circumference, and blood pressure in an adult population in Ahvaz, Iran. *Saudi Med J*. 2014;35(9):967–974.
30. Ludwig DS, Pereira MA, Kroenke CH, et al. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. *JAMA*. 1999;282(16):1539–1546. doi:10.1001/jama.282.16.1539

31. Buendia JR, Li Y, Hu FB, Cabral HJ, Bradlee ML. Regular yogurt intake and risk of cardiovascular disease among hypertensive adults. *Am J Hypertens*. 2018;31:456.
32. McGrane MM, Essery E, Obbagy J, et al. Dairy consumption, blood pressure, and risk of hypertension: an evidence-based review of recent literature. *Curr Cardiovasc Risk Rep*. 2011;5(4):287–298.
33. Njelekela M, Sato T, Nara Y, et al. Nutritional variation and cardiovascular risk factors in Tanzania—rural-urban difference. *South Afr Med J*. 2003;93(4):295–299.
34. Shin J-Y, Kim J-M, Kim Y. Associations between dietary patterns and hypertension among Korean adults: the Korean National Health and Nutrition Examination Survey (2008–2010). *Nutr Res Pract*. 2013;7(3):224–232. doi:10.4162/nrp.2013.7.3.224
35. Schwingshackl L, Schwedhelm C, Hoffmann G, Knuppel S, Iqbal K. Food groups and risk of hypertension: a systematic review and dose-response meta-analysis of prospective studies. *Adv Nutr*. 2017;8:4532.
36. Diarz EJ, Leyaro BJ, Kivuyo SL, et al. Red meat consumption and its association with hypertension and hyperlipidaemia among adult Maasai pastoralists of Ngorongoro Conservation Area, Tanzania. *PLoS One*. 2020;15(6):e0233777. doi:10.1371/journal.pone.0233777