Urban and rural dietary patterns are associated with anthropometric and biochemical indicators of nutritional status of adolescent Mozambican girls

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Ethical standards disclosure: This study was conducted according to the guidelines in the Declaration of Helsinki, and all procedures involving human subjects were approved by the National Ethical Committee at the Ministry of Health in Mozambique. Written informed consent was obtained from all participants and from their guardians if they were under 18 years of age at recruitment.

Abstract

Objective: The objective of this study was to explore whether dietary patterns (DPs) are associated with nutritional status indicators among adolescent Mozambican girls.

Design/Setting/Subjects: In this population-based cross-sectional study we used the food frequency questionnaire data of 547 girls aged 14-19 years from Central Mozambique to derive dietary patterns by means of principal component analysis. We used two-level linear regression models to examine the associations between the DPs and anthropometric and biochemical indicators of nutritional status.

Results: We identified three DPs: 'Urban bread and fats', 'Rural meat and vegetables', and 'Rural cassava and coconut'. The Urban bread and fats DP was positively associated with body mass index-for-age Z-score (BMIZ), mid-upper-arm circumference (MUAC), triceps skinfold (P for all < 0.001), and blood haemoglobin (P = 0.025). A negative association was observed between Urban bread and fats DP and serum folate ($P < 0.001$). The Rural meat and vegetables DP, and the Rural cassava and coconut DP associated negatively with BMIZ, MUAC, and triceps skinfold (P for all < 0.05), but the Rural meat and vegetables DP associated positively with serum ferritin (P = 0.007).

Conclusions: Urban and rural DPs were associated with nutritional status indicators. In a low-resource setting, urban diet may promote body fat storage and blood haemoglobin concentrations but compromise serum folate concentration. It is important to continue valuing the traditional, rural foods that are high in folate.

Keywords

Dietary pattern, nutritional status, adolescent, undernutrition, nutrition transition, Sub-Saharan Africa, Mozambique, low-income country

Introduction

Chronic undernutrition prevails as a public health problem in sub-Saharan Africa, and prevents countries and individuals from developing to their full capacity[1, 2]. During the past decade, the scientific community has started paying more attention to the nutritional and health status of adolescents. Patton et al. (2012) concluded that the adolescent health situation is the worst in sub-Saharan Africa, with persisting high mortality due to maternal and infectious causes[3]. According to several human development indices, Mozambique is at a very low stage of human development[4]. Adolescent pregnancies are common, and 48% of girls are married before the age of 18[5, 6]. These issues threaten the health and development of this age group of girls, who also face the double burden of malnutrition. Indeed, both high prevalence of undernutrition (stunting, anaemia as well as poor zinc, vitamin A and iodine status)[5, 7] and overweight[8] have been reported among Mozambican adolescent girls.

The double burden of malnutrition may indicate a nutrition transition from receding famine towards a phase of increased non-communicable diseases *via* changes in dietary patterns (DP)[9]. Nutrition transition arises from economic growth and urbanisation, and is characterised by reduced physical activity, a low intake of vegetables, and a supply of and preferences for 'fast foods' or 'western-type' foods[10, 11]. An increased consumption of foods high in fat, sugar, and refined carbohydrates but low in fibre and micronutrients, leads to problems of overnutrition, and may finally also cause a rise in chronic diseases in sub-Saharan Africa[10, 11]. Mozambique is estimated to be at the early stage of a nutrition transition[12]. Cross-sectional surveillance data from Mozambique have shown rural-urban differences in fruit and vegetable consumption[13], body mass index (BMI)[14], hypertension[15], and physical activity among adults[16].

Valid characterisation of the Mozambican diet is needed, and a data-driven DP analysis is an effective tool to achieve this. Studying the diet as DPs instead of single nutrients or foods has several advantages[17, 18]. Most importantly, while acknowledging that different foods are usually highly correlated with each other, DP gives a more comprehensive reflection of the whole diet[17, 18]. Furthermore, investigating DPs on the basis of food consumption data is a useful method in diverse cultural settings, where continual dynamic cultural transition may exist[19]. Further, understanding the complexity of a diet in the context of a double burden of malnutrition is of interest in exploring how diet associates with actual nutritional status.

Research on DPs has mainly focused on the associations with indicators of non-communicable diseases, in sub-Saharan Africa and other places[19, 20]. Only a few reports exist on DPs as such or on their association with nutritional status indicators in sub-Saharan Africa[21-23]. Moreover, to our knowledge, no studies have focused on DPs among adolescents in sub-Saharan countries. The objective of this study was to investigate the characteristics of DPs and to explore whether certain DPs are associated with the nutritional status of Mozambican adolescent girls in a cross-sectional setting. The markers of nutritional status reflect body composition as well as micronutrient status in the present study.

Participants and Methods

Setting and participants

The ZANE Study (Estudo do Estado Nutricional e da Dieta em Raparigas Adolescentes na Zambezia) was a population-based cross-sectional study. A target sample size of 600 girls was determined based on resources available. Detailed description of recruitment, sampling design and field work methods have been previously published elsewhere[5]. Shortly, two separate samples of adolescent girls were recruited in the Zambézia Province, Central Mozambique in 2010. The first sample was studied in January–February, the 'hunger season' (n = 283) and the second in May–June, the harvest season (n = 268). The sampling was carried out in five areas: 1) Quelimane City, 2) the district town of Maganja da Costa, 3) rural villages in Maganja da Costa, 4) the district town of Morrumbala, and 5) rural villages in Morrumbala. Girls were recruited from a total of 40 different localities within these five areas. The localities (neighborhoods (*bairros*) or villages) were sampled using probability proportional to size sampling (in the city and district towns, where population figures were available) or random sampling (in the rural areas where population figures were unknown). Within each locality, local recruiters were instructed to follow a recruitment plan while moving from house to house to recruit girls. In the current paper, we divided the area into two categories: Quelimane City, which is referred to as 'Urban', and district towns and rural villages, which is referred to as 'Rural districts'.

If the participant's date of birth was not known, it was estimated with the help of family members. A total of 551 girls were studied. In this paper, we used the data on all girls who participated in a food frequency questionnaire (FFQ) interview (n=547). These participants were adolescent girls aged 14–19 years.

Written informed consent was obtained from all participants and from their guardians if they were under 18 years of age at recruitment. This study was conducted according to the guidelines in the Declaration of Helsinki, and all procedures involving human subjects were approved by the National Ethical Committee at the Ministry of Health in Mozambique. The study was registered at ClinicalTrials.gov (NCT01944891).

Background information and dietary assessment

A background interview and a FFQ interview were conducted[(5)]. An asset score was calculated on the basis of the household's ownership of items such as radios or bicycles, or other background variables such as type of sanitation facility (for details, see[(24)]). The interview included questions on whether the girl was pregnant or breastfeeding a child at the time of the interview. Literacy was defined as the ability to read a short test sentence in Portuguese. A Household Hunger Scale[(25)] score was calculated for each participant. The scale is based on three main questions, asking whether a specific condition of food insecurity ever occurred during the previous four weeks, and the frequency of occurrence. For example, one question was: did you or any household member go to sleep at night hungry because there was not enough food? The possible range of the score is 0-6[(25)]. Score of 0 to 1 was categorised as little or no household hunger and 2 to 6 as moderate or severe household hunger.

For this paper, we used information on the consumption frequency of all food items reported by 3% or more of the participants (a total of 53 items). Of these, 37 items were included in the FFQ and 16 were derived from the FFQ's empty lines reserved for additional foods mentioned by respondents during the interview[(5)]. The additional 16 items were juice, soft drinks, pineapples, oranges, tangerines, guavas, apples, *jambalau* fruit, potatoes, okra, green peppers, carrots, cucumbers, yams, taro, and pasta. During the FFQ interview, participants were asked to estimate how many times they had consumed different foods during the past seven days. They could choose from six categories: none, 1–2, 3–4, 5–6, or 7 times per week, and more than 7 times per week. These were transformed into continuous frequency variables using the following values: 0, 1.5, 3.5, 5.5, 7, and 10. Portion sizes were not elicited.

Anthropometry and laboratory analyses

Height was measured using a stadiometer and recorded to the nearest 0.1 cm. Weight was measuredusing a digital scale and recorded to the nearest 100 g. Mid-upper-arm circumference (MUAC) was measured twice using inelastic circumference measuring tape and recorded to the nearest 0.1 cm. The mean of two measurements was used. Triceps skinfold was measured using a

Harpenden Skinfold Caliper (Baty International, UK). The anatomical sites were carefully located and marked. Three measurements of each skinfold were taken without releasing the grasp of the skinfold. If the results varied by more than 1 mm, the measurements were repeated. The final value for each skinfold was the mean of the three measurements. BMI-for-age z-scores (BMIZ) were generated with IBM SPSS Statistical programme (version 22) using a macro provided by the World Health Organization[(26)]. We used MUAC, triceps skinfold and BMIZ to reflect the fat mass of the body.

Pregnancy was tested from urine samples. If a pregnancy test result was not available, information from the background interview was used to define pregnancy status. Information on the trimester of pregnancy was not available. Venous blood samples (EDTA blood and serum) were drawn by laboratory technicians. Blood haemoglobin concentration was tested using the HemoCue® 301 system. Serum high-sensitivity C-reactive protein (hsCRP), ferritin, and folate, as well as plasma retinol concentration were analysed in the National Institute for Health and Welfare, Finland (Laboratory accredited by Finas T077 (EN ISO-IEC 17025). Serum zinc concentration was analysed in MTT Agrifood Research Finland. A comprehensive description of blood analysis methods has been previously reported[(7)]. As infections may affect ferritin, retinol and zinc concentrations in the blood[(27-29)], only results from participants with hsCRP less than 5 mg/l were included in the statistical analyses of these nutrients.

Statistical analyses

Missing values for asset score items, literacy, pregnancy, and breastfeeding were imputed by hot deck imputation, using area (five categories) as a deck variable. In addition, missing values for FFQ items and HHS were imputed using area and season as deck variables. The number of missing values in the FFQ ranged from 0 for foods such as rice and thick maize porridge to 15 (3%) for yam and taro. As missing values for anthropometric and biochemical variables were not imputed, the number of girls included in each analysis varied.

Principal component analysis (PCA) was applied to create DPs based on the consumption frequency data of the 53 food items. We created DPs from food only and did not include dietary supplements in the PCA. PCA retained 16 DPs with an Eigen value over 1. The first four DPs were initially chosen on the basis of a scree plot. The analysis was then rerun with a forced four-component solution and, to reduce correlation between components, Varimax (orthogonal) rotation was applied. After this, the first three DPs were interpretable and were chosen for analysis. A standardized regression based DP score was calculated for each girl for each of the components identified. This represents the girl's adherence to each DPs.

One-way ANOVA and independent t-tests were used to test the associations between background indicators and DP scores. Multivariate models were used to examine the associations between DP scores with nutritional status indicators. This was done using two-level random intercept linear regression models, taking into account the clustering of participants in localities. Locality (n = 40) was treated as the higher-level unit and the individual girls as the lower-level unit. All models were adjusted for age, season, breastfeeding status, and pregnancy status. An exception was the model for BMIZ, which excluded pregnant girls and was only adjusted for season and breastfeeding status. The number of girls who reported consumption of any type of dietary supplements was small (n=17) and therefore we did not adjust the models for use of dietary supplements. The two-level regression analyses were carried out using SAS 9.4 (proc mixed covtest) and all other analyses were conducted using IBM SPSS Statistics version 22. P values of < 0.05 were considered significant.

Results

The mean age of the participants was 16 years (range: 14–19). The mean age of the non-pregnant girls was 16 years and of the pregnant girls 17 years. Participants characteristics are presented in Table 1, and statistics of the nutritional status indicators are presented in Table 2.

The three DPs explained altogether 24%, and the first, second and third DPs explained 11%, 7% and 7% of the total variance in food frequencies, respectively. The first DP was characterised by high loadings of bread, tomatoes, onions, margarine & butter, rice, oil, sugar, potatoes, eggs, green peppers, soft drinks, juice, fish, sweets, and buns, and was called ‘Urban bread and fats’ (Table 3). The second DP was characterised by foods such as meat, poultry, pumpkins, okra, organs, bananas, other cereals (sorghum, millet), cookies, maize cobs, groundnuts, papayas, boiled cassava, dark green leafy vegetables, beans & peas, and yam, and was called ‘Rural meat and vegetables’. The third DP was characterised by foods such as coconut, cassava porridge, mangoes, sweet potatoes, shrimps, cashew nuts, and taro, and was called ‘Rural cassava and coconut’. DP scores ranged from -2.30 to 2.86 for the Urban bread and fats DP, -1.59 to 5.09 for the Rural meat and vegetables DP, and -1.85 to 4.24 for the Rural cassava and coconut DP.

Table 4 shows the mean DP scores according to sociodemographic characteristics. Girls who adhered to the urban bread and fats DP were more likely to live in an urban area, to be literate, to have little or no household hunger, and to have higher asset scores than other girls. Strong adherence to the Rural meat and vegetables DP was more evident among girls who lived in rural areas, who were illiterate, and who had little or no household hunger. Girls strongly adhering to the Rural cassava and coconut DP were more likely to have been studied in the hunger season (January–February) and lived in a rural area compared to other girls.

The Urban bread and fats DP was positively associated with BMIZ, MUAC, triceps skinfold, and blood haemoglobin, and negatively associated with serum folate concentration (Tables 5 and 6). The Rural meat and vegetables DP and the Rural cassava and coconut DP were both negatively associated with BMIZ, MUAC and triceps skinfold. However, the rural meat and vegetables DP was positively associated with serum ferritin. None of the DPs were associated with serum zinc or plasma retinol concentrations.

Discussion

To our knowledge, the current study was the first to examine whether dietary patterns are associated with anthropometric and biochemical indicators of nutritional status of adolescents in sub-Saharan Africa. We studied Mozambican girls in a cross-sectional setting and identified three DPs: Urban bread and fats, Rural meat and vegetables, and Rural cassava and coconut. The Urban bread and fats DP was associated with a higher blood haemoglobin and anthropometric indices but was negatively associated with serum folate concentration. In contrast, the two different rural DPs were negatively associated with anthropometric indices. The Rural meat and vegetables DP was positively associated with serum ferritin concentration, whereas the Rural cassava and coconut DP was not associated with any of the micronutrient status indicators studied. Our findings show that firstly, in our study population of adolescent girls living in poor socioeconomic conditions, DPs were strongly related to anthropometric indices of nutritional status. Secondly, urban diet had concurrent negative and positive associations with nutritional status, while rural diets had positive or no associations with micronutrient status. These results underscore that moving towards a more urban diet in Mozambique may compromise folate status.

Although food cultures differ in sub-Saharan Africa, and dietary assessment methods vary among studies, the Mozambican DPs had similar characteristics to those of DPs identified elsewhere in sub-Saharan Africa. The Urban bread and fats DP included refined energy-dense foods such as butter, sugar, soft drinks, sweets and buns, but also foods that are regarded as healthy, such as vegetables and fish. These findings are in line with previous reports from sub-Saharan Africa that have found DPs called ‘Purchase’, ‘Urban’, ‘Fat’/’animal’, ‘Vegetables and bread’, ‘Snacking’ or ‘Wheat-based products'[20, 22, 23, 30-33]. Furthermore, similarly to our results, studies in Ghana and Burkina Faso found traditional DPs that included fruits, green leafy vegetables, maize, local cereals, and legumes[20, 23]. In our study, the Rural meat and vegetables DP correlated with frequent consumption of different meat and poultry, which are usually associated with urban dietary habits in sub-Saharan Africa[19, 23]. However, the girls in our study ate only very small amounts of meat and poultry (unpublished data).

The classical nutrition transition from a 'cereals predominant' to 'more fat' diet usually starts from urban surroundings and is related to increased adiposity[9]. Our study was cross-sectional and thus does not describe a direct nutrition transition, which is a temporal process. Nevertheless, our results may offer some insight into the type of consequences that are likely to follow if the Mozambican population adopts more urban type diets with a high intake of energy-dense foods and a low intake of nutrient-dense foods such as folate-rich green leafy vegetables and fruits. It has been suggested that some valuable traditional foods are partly lost in urbanised diets[19]. Indeed, our finding that lower folate status associated with an urban diet is of concern due to the importance of folate for brain health during pregnancy and later life[34]; and in more general, because folate is a biomarker for vegetable and fruit consumption[35], which in turn is important in the prevention of non-communicable diseases.

In the context of our study population, the results showing that the urban diet had positive and the rural diets negative associations with anthropometric indices of nutritional status are not as such comparable to results in highly developed countries with little or no undernutrition. The majority of our study participants were in the normal BMIZ range; the few overweight girls lived in an urban area. We found no obesity in this study population[5]. Furthermore, stunting was prevalent in both the urban and the rural areas[5], suggesting that the population has suffered from undernutrition during childhood. On one hand, the positive association between the urban diet and the anthropometric indices reflecting body fat may indicate a risk of increase in overweight if this nutrition transition continues in the future. On the other hand, the Rural cassava and coconut DP seemed more monotonous than the other DPs, and was dominated by starchy foods. Thus, the negative associations between rural DP and anthropometric indices could be viewed more as a sign of undernutrition than desirable leanness.

Poor iron status, seen as low blood haemoglobin and ferritin concentrations, was prevalent in our study. In this context, finding a positive relationship between the Rural meat and vegetables DP and serum ferritin is important, as it highlights the valuable aspects of the rural diet. In contrast to our results, Zeba et al. (2014) reported inferior nutritional status measured as blood haemoglobin, ferritin and retinol among adults with a traditional diet compared to the urban diet in Burkina Faso[23]. They suggested this was due to meat consumption in the urban diet, and low bioavailability of these nutrients in the traditional diet[23].

Our study had some limitations that should be noted. Applying DP analysis involves subjective decision-making (selection of the food items included in the PCA and the choice of and naming of the DPs)[36, 37].Using data-driven PCA to retain DPs also limits the generalisation of these results[36]. However, a previous study in 12 different countries, including two sub-Saharan countries, discovered two similar DPs across all study sites, despite the high variation in culture and economic development[38]. Thus, it can be suggested that DPs have significant similarities in diverse settings[19]. As we used a large number of food items (53) to derive DPs, the DPs explained a moderate proportion (24%) of the variance in diet. A similar proportion of variance explained was found in a previous study from Sub-Saharan Africa[30]. Our FFQ was not validated, and the possibility of misreporting food frequencies cannot be ruled out. Finally, due to the cross-sectional study design, we were unable to determine a causal relationship between DPs and nutritional status. Nonetheless, our study also has some strengths. It covered two distinct seasons and different regions with diversified urbanisation levels. Thus, our data provides a good representation of the adolescent girls in Central Mozambique. The two-level statistical model used enabled us to reliably investigate the associations between diet and nutritional status.

To conclude, our study suggests that Mozambican adolescent girls are at risk of a double burden of malnutrition in urban areas. Micronutrient-rich foods from rural diets should not be discarded while moving towards a more urban diet. Adolescent girls and their future children would benefit from nutrition and health interventions.

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Table 1. Descriptive information on participants (adolescent girls in Central Mozambique, year 2010, n=547)[1].

	n	**Descriptive statistics**
Age, mean, SD (range)	547	16, 1 (14-19)
Season when the girl was studied		
January-February	281	51%
May-June	266	49%
Place of residency		
Urban	179	33%
Rural districts	368	67%
Literacy		
Illiterate	290	54%
Literate	247	46%
Household hunger scale[2]		
Little or no household hunger	440	81%
Moderate or severe household hunger	101	19%
Asset score, mean, SD (range)[3]	547	20, 7 (5-44)
Household's ownership of a fridge[4]		
Yes	470	14%
No	77	86%
Household's ownership of a bicycle[4]		
Yes	327	60%
No	220	40%
Household's ownership of a motorbike[4]		
Yes	60	11%
No	484	89%
Household's ownership of a car[4]		
Yes	11	2%
No	538	98%

[1] Note that n does not always add up to 547 due to missing data.

[2] Based on questions the experience of household food deprivation during the past month (for details see Ballard et al. 2011[(25)])

[3] The mean asset score was calculated using data that includes imputed values for missing items. Theoretical score minimum and maximum were 0 and 45 (for details see Korkalo et al. 2017[(24)])

[4] Examples of items belonging to the asset score (without imputation of missing data).

Table 2. Nutritional status indicators of adolescent girls.

	Non-pregnant		Pregnant	
	N	Mean (SD)	N	Mean (SD)
BMI-for-age z-score	479	-0.30 (0.84)	60	0.10 (0.67)
Thin or severely thin (< -2 SD), %		2.3		-
Normal weight (-2 to 1 SD), %		92.5		-
Overweight (> 1 SD), %		5.2		-
Mid-upper arm circumference, cm	478	24.5 (2.1)	60	24.4 (2.0)
Triceps skinfold, mm	478	13.0 (4.3)	60	12.1 (3.7)
Haemoglobin, g/l	464	120 (16)	59	111 (17)
Low haemoglobin (< 120 g/l), %		42.7		-
Serum ferritin, µg/l[1]	407	24.9 (17.3)	39	23.9 (17.2)
Low serum ferritin (< 15 ug/l), %		37.6		-
Serum zinc, µmol/l[1]	402	9.6 (2.3)	39	9.2 (2.2)
Low serum zinc (< 9 ug/l), %		37.1		-
Plasma retinol, µmol/l[1]	405	0.90 (0.20)	39	0.78 (0.20)
Low plasma retinol (≤ 0.70 umol/l), %		15.8		-
Serum folate, nmol/l	446	23.2 (10.4)	57	21.8 (10.3)
Low serum folate (< 10 nmol/l), %		9.4		-

[1]Includes only participants with high-sensitivity C-reactive protein <5 mg/l.
* WHO cut-offs were used for haemoglobin(39), ferritin(27), retinol(28) and folate(40) , and International Zinc Nutrition Consultative Group cut-off for zinc(41).
Dash (-) means not applicable.

Table 3. Factor-loading matrix for dietary patterns identified by principal component analysis and Varimax rotation.[1]

Food	Urban bread and fats	Rural meat and fruits	Rural cassava and coconut
Bread	**0.75**	0.11	0.04
Tomatoes	**0.72**	0.03	-0.11
Onions	**0.66**	-0.15	0.17
Margarine, butter	**0.66**	-0.03	0.04
Rice	**0.63**	-0.21	0.11
Oil	**0.53**	0.04	-0.10
Sugar, sugar cane	**0.45**	0.22	-0.06
Potatoes	**0.45**	0.02	-0.03
Eggs	**0.45**	**0.32**	0.19
Green peppers	**0.41**	-0.07	-0.14
Soft drinks	**0.40**	0.05	-0.06
Juice	**0.36**	0.15	0.04
Fish	**0.36**	-0.22	0.11
Sweets, chocolate	**0.33**	0.14	0.13
Buns, doughnuts	**0.31**	0.22	-0.01
Meat	0.25	**0.61**	0.03
Poultry	0.13	**0.57**	0.04
Pumpkins	0.10	**0.55**	0.07
Okra (ladies' fingers)	-0.01	**0.53**	-0.05
Organs	0.17	**0.49**	0.04
Bananas	0.10	**0.49**	0.05
Other cereals (sorghum, millet)	-0.17	**0.47**	-0.08
Cookies, biscuits	0.18	**0.46**	0.25
Maize cobs	-0.11	**0.42**	-0.06
Groundnuts	0.03	**0.41**	0.04
Papayas, ripe	-0.02	**0.41**	**0.38**
Cassava, boiled	-0.12	**0.40**	-0.20
Dark green leafy vegetables	**-0.31**	**0.34**	-0.10
Beans, peas	0.22	**0.33**	0.25
Papaya, green	0.15	**0.32**	0.18
Yams	0.02	**0.32**	0.06
Coconut, coconut milk	0.23	-0.24	**0.59**
Thick cassava porridge	**-0.34**	-0.13	**0.56**
Mangoes, ripe	-0.02	-0.07	**0.53**
White-fleshed sweet potatoes	0.04	0.14	**0.51**
Shrimps	0.25	-0.01	**0.49**
Orange-fleshed sweet potatoes	0.14	0.10	**0.47**
Cashew nuts	0.02	0.27	**0.45**
Mangoes, green	-0.02	-0.02	**0.40**
Taro	0.03	0.16	**0.36**
Thick maize porridge	0.04	0.22	**-0.56**

[1]For simplicity, foods with no factor loadings above 0.3 or below -0.3 are not shown.

Table 4. Mean dietary pattern (DP) scores according to sociodemographic characteristics (n=547)[1].

	N	Urban bread and fats DP Mean (SD)	Rural meat and fruits DP Mean (SD)	Rural cassava and coconut DP Mean (SD)
Season				
January–February	281	-0.01 (1.06)	-0.06 (0.99)	0.45 (1.02)
May–June	266	0.01 (0.94)	0.07 (1.01)	-0.47 (0.72)
P-value		0.895	0.124	< 0.001
Place of residency				
Urban	179	0.9 (0.84)	-0.36 (0.74)	-0.24 (0.79)
Rural districts	368	-0.44 (0.75)	0.18 (1.06)	0.12 (1.07)
P-value		< 0.001	< 0.001	< 0.001
Literacy				
Illiterate	296	-0.39 (0.86)	0.21 (1.04)	0.003 (1.05)
Literate	251	0.46 (0.95)	-0.24 (0.90)	-0.003 (0.94)
P-value		< 0.001	< 0.001	0.944
Household hunger score				
Little or no household hunger	443	0.05 (1.01)	0.06 (1.04)	-0.03 (0.98)
Moderate or severe household hunger	104	-0.23 (0.92)	-0.27 (0.77)	0.15 (1.08)
P-value		0.010	< 0.001	0.100
Household asset score				
Lowest asset score group	188	-0.60 (0.78)	-0.01 (0.94)	0.10 (1.12)
Middle asset score group	182	-0.08 (0.87)	0.04 (1.02)	-0.04 (0.97)
Highest asset score group	177	0.72 (0.86)	-0.03 (1.04)	-0.07 (0.89)
P-value		< 0.001	0.790	0.235

[1]Independent-samples t-test and oneway ANOVA were used for significance testing.

Table 5. Linear two-level models on association between adolescent Mozambican girls' dietary patterns and anthropometric measurements.

	BMI-for-age z-score[1] (n = 479)		Mid-upper arm circumference, cm (n = 544)[2]		Triceps skinfold, mm (n = 544)[2]	
	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value
Fixed part						
constant	-0.30 (0.12)		19.8 (1.3)		5.0 (2.6)	
'Urban bread and fats' DP	0.17 (0.04)	< 0.001	0.5 (0.1)	< 0.001	0.9 (0.2)	< 0.001
'Rural meat and vegetables' DP	-0.11 (0.04)	0.006	-0.4 (0.1)	< 0.001	-0.7 (0.2)	< 0.001
'Rural cassava and coconut' DP	-0.11 (0.05)	0.019	-0.4 (0.1)	0.001	-0.7 (0.2)	0.002
Random part	Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)	
Locality level	0.04 (0.02)		0.29 (0.14)		0.86 (0.55)	
Individual level	0.61 (0.04)		3.45 (0.22)		14.4 (0.92)	

DP, dietary pattern; SE, standard error

[1] Pregnant girls excluded from analysis. Adjusted for season and breastfeeding status (yes/no).

[2] Adjusted for age, season (January–February/May–June), pregnancy status (yes/no), and breastfeeding status (yes/no)

Table 6. Linear two-level models on association between adolescent Mozambican girls' dietary patterns and biochemical indicators of nutritional status.

	Haemoglobin, g/l (n = 527)[1]		Ferritin, µg/l (n = 448)[2]		Zinc, µmol/l (n = 443)[2]		Retinol, µmol/l (n = 446)[2]		Folate, nmol/l (n = 507)[1]	
	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value	β (SE)	P-value
Fixed part										
Constant	131.3 (10.4)		52.7 (12.3)		9.62 (1.74)		0.74 (0.15)		30.4 (5.6)	
'Urban bread and fats' DP	1.9 (0.8)	0.025	-1.5 (0.9)	0.115	-0.12 (0.13)	0.374	-0.02 (0.01)	0.119	-2.2 (0.5)	< 0.001
'Rural meat and vegetables' DP	0.2 (0.8)	0.814	2.4 (0.9)	0.007	-0.04 (0.13)	0.779	0.00 (0.01)	0.955	0.7 (0.4)	0.099
'Rural cassava and coconut' DP	-0.9 (0.9)	0.297	-1.3 (1.0)	0.209	0.05 (0.14)	0.709	0.01 (0.01)	0.227	0.8 (0.5)	0.114
Random part	Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)		Variance estimate (SE)	
Locality level	14.0 (8.5)		19.6 (11.9)		0.46 (0.22)		0.001 (0.001)		16.9 (5.9)	
Individual level	226.4 (14.7)		250.9 (17.9)		5.02 (0.35)		0.036 (0.003)		58.0 (3.9)	

DP, dietary pattern; SE, standard error

[1] Adjusted for age, season, pregnancy status (yes/no), and breastfeeding status (yes/no).

[2] Includes only participants with high-sensitivity C-reactive protein < 5 mg/ l. Adjusted for age, season, pregnancy status (yes/no), breastfeeding status (yes/no).