Original Research

Association between Diet Quality and Nutritional Status among Secondary School Adolescents in Mbeya City

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Abstract

Background: Adolescence is a critical phase of life because it involves changes that are crucial to a person's health and well-being. There is a coexistence of overnutrition and undernutrition among adolescents. Poor diet is among the causes of malnutrition, but little is still known about the quality of diet among adolescents in Tanzania.

Objective: The study's objective was to assess diet quality among adolescents by using the Diet Quality Index International (DQI-I) and assess its association with adolescents' nutritional status in Mbeya City, Tanzania.

Methods: This study used cross-sectional data from Mbeya City, involving 192 adolescents. Anthropometric measurements (heights and weights) were collected, and z-scores were calculated based on the 2007 WHO growth standards for age and sex. Information on demographics and diet was collected through face-to-face interviews using a structured questionnaire. Diet quality score and its component scores were established by the use of the Diet Quality Index- International (DQI-I). Descriptive statistics, Chi-square test, and multinomial logistic regression were used to establish prevalence, means, standard deviation, and the association between variables.

Results: There was a coexistence of undernutrition (stunting: 58.3%, underweight: 29.0%, and thinness: 21.4%) and overnutrition (overweight: 5.8%). The mean diet quality score was 56.66 (SD=8.97). Diet quality score and all its components did not show a significant association with nutritional status except for diet variety which was associated with thinness (AOR= 0.85(95% CI 0.75-0.97), p=0.01).

Conclusion: There is a coexistence of undernutrition and overweight among secondary school adolescents, along with poor diet quality. This highlights the need for further research and targeted intervention.

Keywords: *Double Burden of Malnutrition; Diet Quality Index International; Adolescents Diet*

Introduction

Adolescence is the phase of life between childhood and adulthood, ranging from ages 10 to 19. It is considered a critical phase because it involves rapid growth and development, which immutably affects a person's health and well-being (1). The coexistence of overweight, obesity, and undernutrition affects all populations, including adolescents. Globally, 17.3% of adolescents are overweight, while 8.4% of girls and 17.5% of boys are thin (2). In Africa, the prevalence of overweight among adolescents ranges from 5% to 16.5%, and the prevalence of underweight among adolescents in sub-Saharan countries ranges from 4.5% to 37.8% (3-4). In Tanzania, the 2019 Student Malaria Nutrition Survey found that 20.2% of adolescents are thin, 45.8% are stunted, and 5% are overweight or obese (5).

Poor diet quality is one of the main factors contributing to malnutrition among adolescents (6). Adolescents commonly consume insufficient amounts of fruits, vegetables, and whole grains, while eating excessive amounts of fat, sodium, cholesterol, and added sugars (7-8). Diet quality is defined as the degree to which a diet reduces the risk of non-communicable diseases (8). It encompasses four key aspects: variety (or diversity within and across food groups), adequacy (the sufficiency of nutrients compared to requirements), moderation (restraint in consuming certain foods and nutrients), and balance (the proportion of macronutrient intake and food safety exposure) (9).

Diet quality is typically assessed using Diet Quality Indices (DQIs), which are tools designed to quantify the overall quality of an individual's dietary intake by scoring food and/or nutrient intakes, and sometimes lifestyle factors, based on how closely they align with dietary guidelines (8). These scores are based on food group consumption and nutrient intake (10). A prominent tool, DQI-I, was developed as a modification of indices such as the Diet Quality Index and Healthy Eating Index to capture the major components of a high-quality diet: variety, adequacy, moderation, and balance. The DQI-I addresses concerns about both chronic diseases and undernutrition by providing a comprehensive picture of an individuals dietary health and enabling comparisons across different populations (11).

In Tanzania, the diet quality of adolescents was once assessed using the Diet Quality Score Subscale, which revealed that their diets were characterized by high intakes of cereal grains and legumes (such as beans, peas, and nuts) and increasing consumption of high-calorie foods (5). Adolescents in Tanzania are at particular risk of malnutrition, not only because of increased nutritional requirements and biological factors, but also due to a lack of adequate research, nutritional programmes, and interventions targeting this age group (12). While previous studies have used dietary diversity as a proxy for diet quality, this approach provides limited insight into other important aspects, such as adequacy, moderation, and overall balance, which significantly affect adolescents' nutritional status (5-6).

Consequently, this study aimed to fill this gap by examining additional aspects of diet

quality variety, adequacy, moderation, and overall balance and assessing their association with nutritional status using the DQI-I among adolescents in Mbeya City, Tanzania. The findings will provide a baseline for developing effective interventions to improve the diet quality and food environment of Tanzanian adolescents.

Materials and Methods

Study design

A cross-sectional study was conducted in Mbeya City, Tanzania, to assess the association between diet quality and nutritional status among adolescents.

Study setting

Mbeya City covers an area of 222 square kilometers, with 46.4% of the land used for agriculture and 53.6% for other uses such as settlements, forestry, valleys, and mountain ranges. The city has a population of 385,279 inhabitants, with 47% male and 53% female (13). The Mbeya City is located in a highland region characterized by a moderate climate and sufficient rainfall, supporting agriculture as a major economic activity. The city comprises 36 wards and 51 secondary schools (including 23 private schools) and is known for high levels of stunting, overweight, and obesity among adolescents (5).

Sample size and sampling technique

A multistage sampling approach was employed to select participants from both public and private Ordinary-Level secondary schools (Form 1 to Form 4). The study population consisted of adolescent students aged 14 to 19 years, since they are the ones who can be found in secondary school settings. Four wards were purposively selected based on the availability of both public and private day schools. From each ward, one private and one public day school were randomly selected, resulting in eight participating schools. In each selected school, 48 students were stratified and randomly selected, considering gender and form (Form 1 to 4). A sample size of 384 adolescents was calculated using Kothari's formula (14), assuming a 95% confidence level (Z = 1.96), a prevalence (p) of 50%, and a margin of error of 5%. All students who did not give consent to participate in the dietary assessment were excluded from the study to ensure uniformity in dietary patterns.

Data Collection

Socio-demographic and dietary data

Data were collected using a structured, interviewer-administered questionnaire, which was first prepared in English and then translated into Kiswahili. The questionnaire was pretested in a school other than those included in the study and was administered by a trained interviewer. The information collected captured participants' socio-demographic characteristics, dietary intake, and anthropometric measurements.

Anthropometric measurements

Standard procedures (15) were followed to measure the weight and height of all participants. Weight was measured with bare feet and light clothing using an electronic scale to the nearest 0.1 kg. Height was measured to the nearest 0.1 cm using a standard height board. Tools were pretested to ensure that students were measured in a secluded area provided inside schools by a trained researcher to ensure accuracy and confidentiality.

The measurements were entered into the WHO AnthroPlus software to generate Z-scores and classify participants according to the WHO reference population. Participants were classified as stunted (height-for-age Z-score < -2SD), thin (BMI-for-age Z-score < -2SD), overweight (BMI-for-age Z-score > 1SD), or obese (BMI-for-age Z-score > 2SD) (16).

Diet quality assessment

A 24-hour dietary recall was employed to assess participants' food consumption. Participants were asked to recall all foods and beverages consumed in the 24 hours preceding the survey. The recall was administered using the multiple-pass method (17) to ensure accuracy. Pictures and portion size props from the STEP survey (18) and the Dietary Assessment and Educational Kit (19) were used to estimate portion sizes. Nutrient intake was determined using the Tanzania Food Composition Table (20) and calculated by NutriSurvey software (2007, EBISpro, Willstätt, Germany).

The DQI-I was employed to calculate diet quality scores, with consideration for age- and sex-specific dietary recommendations (21). The DQI-I assesses four components of diet quality: variety, adequacy, moderation, and overall balance. The score ranges from 0 to 100, with higher scores indicating better dietary quality. Dietary variety (0-20 points) captures the diversity in food groups and protein sources. Dietary adequacy (0-40 points) assesses the intake of key food groups and nutrients. Dietary moderation (0-30 points) evaluates the intake of total fat, saturated fat, cholesterol, sodium, and empty-calorie foods. Overall balance (0-10 points) assesses the proportion of energy from carbohydrates, protein, fat, and fatty acids (22).

Data analysis

Data were analyzed using SPSS (version 21, IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies, and percentages, were used to summarize demographic characteristics and nutritional status. The diet quality scores were normally distributed, as determined by the Shapiro-Wilk test ($p > 0.05$), and are presented as mean ± SD. A Chi-square test was applied to examine differences in diet quality across demographic variables. Multinomial logistic regression was employed since the dependent variable is categorical; it was used to assess the association between diet quality (independent variable) and nutritional status (dependent variable). Age, sex, level of education and type of school adolescents attend were identified as potential confounders therefore used to adjust the predictor variable. A significance level of $p<0.05$ was used to determine statistical significance.

Ethical considerations

Ethical approval for this study was obtained from the National Health Research Ethics Sub-Committee (NatHREC) of the National Institute for Medical Research (NIMR), Tanzania (Reference number: NIMR/HQ/R.8a/Vol.IX/4315). Additional permission was sought from the Regional Administrative Secretary, District Executive Directors, and school authorities. Written informed consent was obtained from the students aged 18 years and older, while for students younger than 18, assent forms were

signed, and they were provided with a consent form to be signed by caregivers/ parents and instructed to provide the signed consent forms from parents during interviews. Confidentiality was maintained throughout the study by anonymizing the respondents with numbers, and interviews were held in a class or office or designated place inside the school with an interviewer with one participant only, and participation was entirely voluntary.

Results

Sociodemographic characteristics

A total of 192 students from eight secondary schools (four private and four public) participated in this study. Of these, 101 (52.6%) were female. The ages of the respondents ranged from 14 to 19 years, with a mean age of 15.5 years (±1.2). Half of the participants (50%) attended private schools, and the majority (44.3%) were in form four. The mean height and weight of the participants were 157.4 cm (±7.3) and 49.4 kg (±7.9), respectively (Table 1).

Nutrition status

The mean Body Mass Index (BMI) for the adolescents was 20.1 (±2.4). According to the Weight-for-Height Z-scores, 133 (68.2%) of the participants were classified as normal, 50 (26.8%) were underweight, and 11 (5.8%) were overweight. When categorized by BMI-for-age Z-scores, the results showed that 136 (69.3%) adolescents had a normal weight, 41 (21.4%) were thin, and 11 (7.8%) were overweight. For Height-for-Age Z-scores, 82 (42.7%) were within the normal range, while 58.3% were classified as mildly, moderately, or severely stunted (Table 1).

Table 1. Socio-demographic characteristics and nutritional status of participants (n = 192)

Characteristic	Category	n (%) or Mean ± SD
Age (years)	Mean ± SD	15.5 ± 1.2
Sex	Male	91 (47.4)
	Female	101 (52.6)
School type	Public	96 (50.0)
	Private	96 (50.0)
Education level	Form I	15 (7.8)
	Form II	34 (17.7)
	Form III	58 (30.2)
	Form IV	85 (44.3)
Height (cm)	Mean ± SD	157.4 ± 7.3
Weight (kg)	Mean ± SD	49.4 ± 7.9
BMI (kg/m²)	Mean ± SD	20.1 ± 2.4
Height-for-age (Z-score)	Normal	82 (42.7)
	Stunted*	110 (57.3)
BMI-for-age (Z-score)	Normal	136 (70.8)
	Thin	41 (21.4)
	Overweight	15 (7.8)
Weight-for-height (Z-score)	Normal	131 (68.2)
	Underweight	50 (26.0)
	Overweight	11 (5.8)

*Includes mild, moderate, and severe stunting.

Diet quality

The mean total DQI-I score was 56.66 (±8.97) out of a possible 100. Among the DQI-I components, adequacy had the highest score, followed by moderation and variety, with overall balance scoring the lowest (Table 2).

Table 2: DQI-I Components Score (n=192)

Component	Category	Full Score	Mean (SD)
DQI-I Total		**0–100**	**56.66±8.97**
Variety	Overall food group variety	0–15	11.24±3.39
	Within-group variety (protein source)	0–5	1.71±1.28
Adequacy		**0-40**	**24.65±4.63**
	Vegetable group	0–5	1.02± 1.79
	Fruit group	0–5	1.49± 1.57
	Grain group	0–5	4.69± 0.73
	Fiber	0–5	3.91± 1.40
	Protein	0–5	3.80± 1.05
	Iron	0–5	3.58± 1.77
	Calcium	0–5	2.08± 1.53
	Vitamin C	0–5	4.07± 1.24
Moderation		**0-30**	**19.36± 4.71**
	Total fat	0–6	3.22± 2.31
	Saturated fatty acid	0–6	0.92± 1.49
	Cholesterol	0–6	5.88± 0.86
	Sodium	0–6	5.61± 1.26
	Empty calorie food	0–6	3.73± 2.25
Overall Balance		**0-10**	**1.41± 1.83**
	Macronutrient ratio	0–6	1.41± 1.83
	Fatty acid ratio	0–4	0.00

SD (Standard Deviation)

In terms of diet variety, only 5.7% of adolescents consumed one or more servings from each food group daily, and 54.7% reported consuming only one source of protein per day. For diet adequacy, more than 50% of the respondents met over half of the recommended intake for grains, protein, vitamin C, iron, fiber, and protein. However, fewer than 50% met the recommended intake for fruits, vegetables, and calcium. Regarding overall balance, only 5.2% of adolescents had the recommended intake ratio of energy from macronutrients, and none achieved a score for the recommended fatty acid ratio (Table 3).

Table 3. Distribution of diet variety, adequacy, diet moderation and balance components among participants (n = 192)

Component	Category	Score range	n (%)
Variety	≥1 serving from each food group/day	15	11 (5.7)
	1 food group missing	12	54 (28.1)
	2 food groups missing	9	87 (45.3)
	≥3 food groups missing	≤6	40 (20.9)
Within-group protein variety	≥3 sources/day	5	10 (5.2)
	2 sources/day	3	58 (30.2)
	1 source/day	1	105 (54.7)
Adequacy	Vegetables ≥100% RDA	5	25 (13.0)
	Fruits ≥100% RDA	5	6 (3.1)
	Grains ≥50% RDA	≥3	162 (84.4)

	Fiber ≥100% RDA	5	110 (57.3)
	Protein ≥100% RDA	5	80 (41.7)
	Iron ≥100% RDA	5	111 (57.8)
	Calcium ≥100% RDA	5	32 (16.7)
	Vitamin C ≥100% RDA	5	116 (60.4)
Moderation	Total fat <20% energy	6	64 (33.3)
	Saturated fat <7% energy	6	3 (1.6)
	Cholesterol <300 mg/day	6	188 (97.9)
	Sodium <2400 mg/day	6	173 (90.1)
	Empty calories <3% energy	6	83 (43.2)
Overall balance	Recommended macronutrient ratio	6	10 (5.2)
	Recommended fatty acid ratio	4	0 (0.0)

RDA = Recommended Dietary Allowance.

Association Between Diet Quality and Nutrition Status

According to the tool's recommendations, a total DQI-I score of 60 marks the threshold for acceptable diet quality. In this study, 121 (63.0%) of the participants had a low diet quality, while 71 (37.0%) achieved a high diet quality score. Chi-square test results indicated no significant differences in diet quality distribution based on demographic characteristics, including gender (p=0.85), school type (p=0.29), level of education (p=0.78), and age (p=0.95), (Table 4).

Table 4. Distribution of diet quality score by socio-demographic characteristics (n = 192)

Characteristic	Category	Low DQI-I n (%)	High DQI-I n (%)	p-value
Sex	Male	58 (63.7)	33 (36.3)	0.85
	Female	63 (62.4)	38 (37.6)	
School type	Public	57 (59.4)	39 (40.6)	0.29
	Private	64 (66.7)	32 (33.3)	
Education level	Form I–II	33 (66.0)	17 (34.0)	0.78
	Form III–IV	88 (61.5)	55 (38.5)	
Age group (years)	14–15	44 (65.7)	23 (34.3)	0.95
	16–19	77 (61.1)	49 (38.9)	

Results from the multinomial logistic regression analysis revealed no significant association between the total diet quality score and the nutritional status of the adolescents. Among the diet quality components, only diet variety showed a significant association with nutritional status. Specifically, diet variety was significantly associated with a reduced risk of being underweight (cOR=0.89 (95%CI 0·75-0·96), p=0.034) and thinness (cOR=0.85 (95%CI 0·79-0·98), p=0.01). After adjusting for age, sex, level of education, and type of school, diet variety remained significantly associated only with thinness (aOR=0.85(95% CI 0.75-0.97), p=0.01), (Table 5).

Table 5: Association between diet quality (independent variable) and nutrition status (dependent variables) among participants (n=192)

Nutrition status		Diet quality score		Variety		Adequacy		Moderation		Overall balance	
	n	cOR	aOR	cOR	aOR	cOR	aOR	cOR	aOR	cOR	aOR
BMI for Age											
Normal	136	1	1	1	1	1	1	1	1	1	1
Overweight	15	0.89 (0.79-0.98)	0.99 (0.88-1.12)	0.91 (0.76-1.10)	0.95 (0.74-1.22)	0.92 (0.82-1.05)	0.92 (0.78-1.10)	1.00 (0.89-1.13)	1.00 (0.89-1.13)	1.05 (0.79-1.39)	1.04 (0.74-1.46)
Thinness	41	1.19 (0.57-2.48)	1.01 (0.93-1.09)	0.85[a] (0.75-0.96)	0.85[a] (0.75-0.97)	1.02 (0.94-1.10)	1.01 (0.90-1.14)	1.00 (0.93-1.08)	1.09 (0.90-1.10)	0.95 (0.78-1.16)	0.93 (0.74-1.18)
Weight for Height											
Normal	131	1	1	1	1	1	1	1	1	1	1
Underweight	50	0.97 (0.90-1.04)	0.97 (0.93-1.01)	0.89[a] (0.79-0.98)	0.89 (0.80-1.00)	0.99 (0.92-1.07)	0.99 (0.91-1.07)	0.98 (0.92-1.06)	0.99 (0.92-1.07)	0.99 (0.82-1.19)	0.99 (0.82-1.20)
Overweight	11	1.08 (0.93-1.25)	1.00 (0.92-1.07)	0.90 (0.73-1.12)	0.91 (0.70-1.17)	0.94 (0.80-1.10)	0.95 (0.80-1.13)	1.09 (0.93-1.28)	1.11 (0.93-1.32)	1.17 (0.84-1.65)	1.16 (0.80-1.67)
Height for age											
Normal	82	1	1	1	1	1	1	1	1	1	1
Stunted	110	1.06 (0·90-1.25)	1.10 (0.92-1.32)	0.91 (0.76-1.09)	0.91 (0.75-1.10)	0.95 (0.79-1.14)	0.91 (0.74-1.11)	0.94 (0.78-1.12)	0.91 (0.75-1.11)	1.06 (0.91-1.24)	1.00 (0.92-1.31)

Multinomial logistic regression, p=0.05, [a] significant value, cOR(Crude Odds Ratio) and aOR(Adjusted Odds Ratio), CI=95%

Discussion

This study explored the association between diet quality and nutritional status among secondary school adolescents. The findings on levels of malnutrition align with previous reports from the region and Tanzania as a whole (5), suggesting that there has been little improvement in adolescent nutrition. This stagnation may be attributed to long-term neglect of nutritional care during adolescence, along with dietary changes influenced by increased autonomy in food choices as adolescents age (8). These results emphasize the need for adolescent-focused research, as malnutrition can have long-term implications, potentially leading to generational cycles of poor nutrition, particularly because this age group is in their reproductive years.

Overall, the diet quality of the adolescents studied fell below the recommended DQI-I standard. A significant portion of their diet in the 24 hours preceding the survey was made up of cereal-based and fried foods, with limited intake of vegetables and fruits. This dietary pattern impacted the overall balance and variety of their diet, consistent with findings from other studies that highlight poor diet quality among adolescents (23).

Diet variety was lacking among most adolescents, as few consumed one serving from each food group or had more than three sources of protein within their diet over the past 24 hours. The majority missed two or more food groups. This might be attributed to the autonomy adolescents have over their food choices (8). Most participants consumed breakfast and lunch during school hours, with dinner at home, where greater dietary diversification was observed. This indicates a potential lack of awareness among adolescents about the importance of a balanced diet and the benefits of family meals for dietary diversity. Similar trends have been reported in other studies (22,24).

In terms of diet adequacy, very few adolescents met the daily recommended intake of vegetables and fruits, although most met the intake requirements for grains. This observation aligns with previous studies in sub-Saharan Africa reporting low fruit and vegetable consumption among adolescents (6). The prevalence of cereal-based foods may be due to their availability; Mbeya is part of the country's food basket and is a major producer of maize and rice, making maize stiff porridge (ugali) and boiled rice staple foods in the region (25).

For diet moderation, most adolescents had moderate intakes of cholesterol and salt, as their diets did not include foods typically high in these components, such as chips or grilled meats, in the 24 hours prior to the study. This differs from findings in other studies, which report increased consumption of junk foods and high-sodium snacks among adolescents (26). One possible reason is that such foods are relatively expensive in the study area, making them less accessible.

No participant achieved a balanced fatty acid ratio, as the diets generally showed an imbalance between unsaturated and saturated fats, with saturated fats being predominant. This could be attributed to the high consumption of oily foods and red meat observed in the participants' 24-hour dietary recall (27). Few adolescents had the recommended macronutrient ratio, with most dietary energy coming from carbohydrates and fats. This finding is consistent with other studies that report high consumption of carbohydrate and fat-rich foods among adolescents (24).

There was no significant difference in diet quality distribution between males and females, different school forms (form 1 to form 4), age categories, or school types (public vs. private). More than 50% of the participants, regardless of their demographic characteristics, appeared to consume diets of low quality. This is concerning from a public health perspective, as poor diet quality can have long-term negative effects on adolescents' health (6).

Contrary to other studies (5-6), this study found no significant association between overall diet quality scores and nutritional status. This discrepancy may be explained by the use of different tools to evaluate diet quality across studies (8). However, the aspect of diet variety did show a significant association with nutritional status, correlating with a reduced risk of thinness among adolescents. This aligns with other research that links high dietary diversity scores to a lower risk of malnutrition (5).

Our study has several limitations that should be acknowledged. First, the cross-sectional design means we cannot infer causal relationships: while we observed significant associations between diet variety and nutritional status (thinness, underweight), both may be affected by other underlying factors. Second, diet quality was measured using self-reported recall which is subject to recall error, misreporting, and social desirability bias. Third, data were collected at a single time-point and may not reflect habitual dietary patterns or seasonal

variation. Fourth, although we adjusted for several potential confounders (age, sex, education level, type of school), residual confounding cannot be ruled out: variables such as physical activity, household food security, parental dietary behaviors, or health status may have influenced both diet quality and nutritional outcomes. Finally, generalizability of our findings may be limited, our sample was drawn from specific schools and region, which may not represent adolescents in other regions, or different cultural contexts. Future longitudinal studies, with repeated dietary assessments and more comprehensive control of confounding, are needed to better clarify the direction and magnitude of the relationships observed.

Conclusions

This study shows the coexistence of undernutrition and overnutrition among secondary school adolescents in Mbeya City, emphasizing the need to treat this as a public health concern. The research found that overall diet quality was poor, with limited dietary variety and inadequate intake of vegetables and fruits, and a predominance of carbohydrate- and fat-rich foods. This highlights significant gaps in diet quality that could contribute to long-term health implications.

A significant finding was that diet variety was associated with a reduced risk of thinness, suggesting its potential role in improving nutritional outcomes. However, other aspects of diet quality did not show a strong link to nutritional status, signaling the need for further longitudinal research to identify other root causes of malnutrition among adolescents.

The study calls for targeted nutrition interventions and more comprehensive research in Tanzania to better support adolescent health and prevent long-term impacts of malnutrition.

Acknowledgements: The authors wish to acknowledge the Department of Nutrition and Consumer Sciences at Sokoine University of Agriculture, for their support during the preparation of this manuscript; Mbeya City council administration for allowing the study to take place in their locality, and secondary school head masters/mistresses of the participated schools for allowing their schools to participate and providing data that made this study possible.

Funding: No funding was received for this research work.

Authors' contributions: Corresponding author conceptualized the study, designed the methodology, conducted data collection and

analysis, and drafted the manuscript. Other authors supervised the study, provided methodological and analytical guidance, and critically reviewed the manuscript for intellectual content. All authors read and approved the final manuscript.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request, subject to ethical approval and institutional permissions.

Consent for publication: Not applicable.

Competing interests: The authors declare that they have no competing interests.

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