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Prevalence and associated factors of undernutrition among adolescents in public schools, Addis Ababa, Ethiopia, 2021

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Abstract

Objectives: Adolescence is a critical period for the accretion and acquisition of adult peak bone mass and a significant proportion of height. Undernutrition during this period has both an immediate and long-term effect on adolescent health, as well as a negative impact on the country's economic productivity, posing social and economic difficulties. Therefore, the aim of this study was to determine the prevalence of undernutrition and associated factors among adolescents attending public schools in Addis Ababa, Ethiopia, 2021.

Methods: A facility-based cross-sectional study was conducted among 678 school adolescents. Participants were chosen using a simple random selection procedure. The data was analyzed using SPSS. The relationship between the dependent and independent variables was investigated using bivariate and multivariable logistic regressions. In multivariable analyses, variables having a P-value less than 0.05 were considered to have significant association with undernutrition.

Results: The overall, prevalence of stunting and thinness was [7.2%:95% CI (5.3–9.3)] and [9%:95% CI (6.8–11.4)] respectively. Stunting was associated with larger family size [AOR = 3.76: 95% CI (1.58-8.94), low dietary diversity [AOR = 2.87: 95% CI (1.44-5.74), food insecurity [AOR = 2.81: 95% CI (1.38-5.71)], and lower wealth index [AOR = 3.34: 95% CI (1.51-7.41)]. While thinness was associated with maternal education [AOR = 2.5: 95% CI (1.97-8.01), inadequate dietary diversity [AOR = 4.81: 95% CI (2.55-9.07)], and family size [AOR = 2.46: 95.0% CI (1.14-5.29)].

Conclusion: stunting and thinness were most common. Thinness was connected to parental education, family size, and individual dietary diversity. Stunting was also linked to household income, family size, food insecurity, and dietary diversity. Therefore, to this a concerted effort at all levels should be made to promote maternal education, household food security, and nutritional diversity.

Keywords: stunting, thinness, adolescence, Addis Ababa, Ethiopia

Introduction

According to WHO, adolescence is defined as the period from 10 to 19 years when an individual undergoes major physical growth, mental development, and psychological changes (1). It is a transition phase where an individual is no longer a child but is not yet an adult. It is the only period in the life span following infancy when the rate of physical growth is highest (2). Suboptimal nutrition during this period leads to a triple burden of malnutrition with consequences for their health and sexual development (2). Adolescents gain up to 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeletal mass as a result of increased dietary needs (3).

However, in low and middle-income countries, malnutrition, particularly undernutrition, is very common among adolescents (2). At the end of 2018, Sub-Saharan Africa had 1.2 billion adolescents, accounting for one-fourth of the population (1). Children and adolescents make up around 48 percent of Ethiopia's overall population (2). Adolescence is a phase of active growth that is defined by profound biochemical, physical, psychological, and social changes (4).

Inadequate nutrition in adolescence can potentially retard growth; decrease learning ability; delay sexual maturity and lack of concentration; impair school performance; undermine physical and economic growth; limit the body's ability to appropriately absorb nutrients; and perpetuate poverty. These are the common consequences of chronic undernutrition in adolescents. Furthermore, malnutrition in adolescence expresses itself in two basic categories: categorized as nutrition (stunting and thinness) (4-7).

Undernutrition during the adolescent period diminishes the working capacity of an individual during adulthood (3). Ultimately, it silently destroys the future socio-economic development of a nation and even causes the cruel cycle of intergenerational undernutrition by sharing the consequences with their children, including low birth weight, short stature, and low resistance to infection (5). This problem would be devastating in Ethiopia, where about 27.7% of adolescent girls become pregnant at the age of nineteen (8). Therefore, the study aims to assess undernutrition and its associated factors among adolescents in Lideta sub city, Addis Ababa, Ethiopia, in 2021.

Methods

Study area and period: the study was conducted in Lideta sub-city, Addis Ababa, Ethiopia. The Lideta sub-city is one of the eleven sub-cities of the Addis Ababa city administration, located in the central part of the town. Information obtained from Lideta's sub-city educational office reported that they had eighteen primary schools and three secondary schools (9). In the academic year of 2020/2021, around 10,033 adolescent students were registered. Of these, 3,431 were in secondary schools and the remaining was in primary schools. The study was conducted from May 20 to June 5, 2021.

Study design: an institution-based cross-sectional study design was employed.

Source population: all adolescent students in public schools enrolled in the 2020/21 academic year in Addis Ababa, Ethiopia.

Study population: all school adolescents (aged 10-19 years) enrolled and available at time of data collection period in public schools of Lideta Sub-city.

Sample size determination

The sample size was calculated by using the single population proportion formula. The magnitude of stunting and thinness from the previous studies was 20.7 and 22% (10, 11), with a precision of 4%, 95% CI and a design effect of 1.5. Because this study has two outcome variables, the larger sample size became 678 after a 10% non-response rate was added.

Sampling technique

For this study, proportional to population size (PPS) with a simple random sampling technique was carried out. Schools were chosen through a lottery method. Primary and secondary schools were represented by a total of 678 students. Each school and class (grades 5 to 12) found in each selected school received a proportional allocation of the sample size. Each school's administrators provided a sampling frame (a list of adolescents aged 10–19 years). Finally, a simple random sample strategy was utilized to pick study participants by using the student list as a sampling frame.

Data collection methods and procedures: four diploma nurses and two BSC health officers were hired as data collectors and supervisors, respectively. Data was collected through a face-to-face interview, using a structured and pre-tested questionnaire.

The data collection began with permission and consent forms from the respondent's family at their residence. The family was quizzed on sociodemographic factors, food security, wealth index, environmental sanitation, and hygiene in their home. The remaining individual dietary information was obtained from the adolescent.

Height measurement

Setting up the measurement site

The height was measured with a stadiometer vertically to a hard flat wall surface with the base at floor level. The vertical location of the rule was checked with a carpenter's level. In the absence of such a floor, a hard wooden platform was placed beneath the height base.

Weight measurement

Setting up the measurement site

It was measured by a weighting scale (model 8811021659, made in Germany). The weighing balance was calibrated in kilograms, and students were weighed to the nearest 0.1 kg while dressed in light clothing and without shoes.

Measuring the dietary diversity score (DDS)

The DDS was used to assess nutritional adequacy, which was defined as the number of food categories ingested in a certain period of time, often 24 hours. Every respondent was asked about the food they had consumed in the previous 24 hours, both inside and outside their home. Obtained as minimal dietary diversity (MDD) from 8 food categories among those who ingested at least 4 food groups on the previous day (24-hour recall). For example, the DDS of eight food categories was used, and it was calculated by taking into account the type and number of food groups consumed by the household (12). Poor dietary diversity was defined as the dietary diversity score below the median value (less than 4 food groups) and good dietary diversity was categorized as adolescents who had a dietary diversity score of the median and above the median values (greater than or equal to 4 food groups) (13).

Measuring food insecurity in households

The household Food Insecurity Access Scale (HFIAS) developed by FANTA was used to determine the level of food insecurity in the household. The scale explores the occurrence and frequency of occurrence of nine food insecurity-related events in the past 30 days of the survey. The household was classified as either food secure or food insecure by the HFIAS (14).

The wealth index procedure

Questions from the Ethiopian demographic and health survey, 2016, were used to determine the wealth level of the households. Through principal component analysis, fourteen major variables were analyzed. The values of each wealth variable were recoded as 0 and 1 before undertaking principal component analysis. Following that, principal component analysis was used to rank the findings from lowest to highest into three groups: poor, medium, and wealthy, which were coded as 1, 2, and 3 respectively.

Operational Definition:

Thinness was taken as a BMI for age (BAZ) value of less than two standard deviations from the WHO Child Growth Standard (15).

Stunting was defined as a height for age (HAZ) value of less than two standard deviations from the WHO Child Growth Standard (15).

Poor dietary diversity: adolescents with a dietary diversity score below the median value of less than 4 food groups (16).

Good dietary diversity: Adolescents were measured using a qualitative recall of all foods consumed by each adolescent during the previous 24 hours through a standardized and validated tool containing 8 food groups taken from verbal reports of the participants, and we considered an adolescent to have adequate dietary diversity if they reported consuming four or more food groups (17).

A food secured household: A household with a score of 0–1 on the Household Food Insecurity Access Scale (HFIAS) is classified as food secure (15).

Food insecure household: Based on (HFIAS) score (0–27) of 2 and above, will be considered as food insecure (18).

Quality control of data

In order to maintain the quality of the data, training was provided to data collectors and supervisors for one day by the principal investigators. The questionnaire was prepared first in English and then translated to the local language, Amharic, and back to English to check its consistency. A pretest was conducted on 5% of the subjects at Addis Ketema sub-city public schools, and the scales were carefully handled and periodically calibrated by placing standard calibration weights of 2 kg iron bars on the scales. On-site supervision was performed, and each copy of the questionnaire was checked for completeness and accuracy before data entry.

Data Processing and Analysis

For cleaning, recoding, and categorizing variables, the collected data was entered into EPI info 3.1 computer programs and exported to the Statistical Package for Social Sciences (SPSS) version 21 for analysis. In addition, WHO Anthro-plus software was used to enter and analyze anthropometric data. PCA (principal component analysis) was used to examine the household wealth index. The Keiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to verify the statistical assumptions of factor analysis. As a result, a KMO of 0.5 or above, as well as a significant Bartlett's test of sphericity (p-value 0.05), were deemed sufficient to satisfy the assumption.

Moreover, communality values and eigenvalues of 0.5 and greater than 1 were included in factor analysis. The variables with less than 0.5 of the communality value were removed from the analysis, and the analysis was done repeatedly until all variables met the inclusion criteria for factor analysis. Next, all eligible factor scores were computed using the regression-based method to generate one variable, wealth status. Then, afterward, the loading factors were sorted in their ascending order. Following this, the final scores were ranked into three quartiles, namely first, second, and third. Finally, ranks were interpreted as poor, middle, and wealthy, respectively. A descriptive summary (frequency distribution, proportion, mean, and standard deviation) was used to summarize the variable.

Binary logistic regression analysis was used to ascertain the association between explanatory and outcome variables. A variable whose coefficient is less than 0.2 in the bivariate analysis was entered into the multivariable analysis to determine factors associated with malnutrition. In the

multivariable analysis, a p-value of less than 0.05 and an odds ratio with 95% CI were used to declare the presence and strength of association.

Patient and public involvement

Throughout the data collection period parents or the legal guardians of the study participants were involved with a free support and advice for the researchers related with ethical issues and advice on how to share our findings to a wide audience, in a way the public can understand.

Result

Socio-demographic characteristics of adolescents and their families.

A total of 678 adolescent students were included in the study with a 100% respondent rate. Males made up nearly half (364, or 53.7%) of the study participants. The average age of the respondents was 15 (SD 2.4) years, with a range of 11 to 19 years. Almost one third (211, or 31.6%) of the study participants were early adolescents. The majority of participants (446, or 65.8%) were from primary schools. In terms of their parents' occupation status, nearly a quarter (173 or 25.5%) of their fathers and 158 (23.3%) of their moms were government employed and housewives, respectively (Table 1).

Table 1: Sociodemographic characteristics of the study participants among adolescent students in a public school in Addis Ababa, Ethiopia (n = 678)

Variables	Category	Frequency	Percent (%)
Sex	Male	364	53.7
	Female	314	46.3
Adolescent age	10-13	219	32.3
	14-16	296	43.7
	17-19	163	24
Adolescent grade	Primary school	446	65.8
	Secondary school	231	34.1
Fathers' educational	Unable to read and write	77	11.4

status	Able to read and write	233	34.4
	Primary education	147	21.7
	Secondary education	106	15.6
	College and above	84	12.4
Mother's education	Unable to read and write	85	12.5
	Able to read and write	147	21.7
	Primary education	167	24.6
	Secondary education	100	14.8
	College and above	80	11.8
Family size	<3	204	30.1
	4-5	217	32
	>5	257	37.9
School feeding	Yes	446	65.8
	No	232	34.1

5.2. Wealth Index

According to wealth classification, 231 (34.1%) of households were asset poor, while 207 (30.5%) and 240 (35.4%) were classified as asset medium and rich HHs, respectively "(figure 1)".

The dietary diversity status of adolescents

The mean (SD) dietary diversity score in the study group was 4.2 (2). The proportion of adolescents who consumed good dietary diversity was 389 (57%) and the proportion of adolescents who consumed poor dietary diversity was 289 (42.6%). The greater proportion of 594 (90.4%) of the study participants consumed food containing cereals, while only 187 (28%) of respondents reported consuming animal products (table 2).

Table 2: Dietary diversity among adolescents in public schools of Addis Ababa, Ethiopia 2021

Variable	Response	Frequency	Percentage
Grains, Root or Tuber	Yes	597	88.1

	No	81	11.9
Vitamin A rich fruit and vegetable.	Yes	401	59.1
	No	277	40.9
Fruits and Vegetables	Yes	350	48.4
	No	328	51.6
Meat, poultry, offal and Fish	Yes	193	28.5
	No	485	71.5
Eggs (eggs)	Yes	199	70.6
	No	479	29.4
Pulses, Legumes, nuts and seeds	Yes	257	37.9
	No	421	62.1
Milk& milk products	Yes	296	43.7
	No	382	56.3
Food cooked Oils and Fats	Yes	532	78.5
	No	146	21.5

Food security status of households

Regarding household food security measurement, the study participants were asked to report the frequency of worrying about what to eat to the range of remaining hunger day and night in the previous four weeks before the survey. Based on the nine HFIAS questions' responses, their frequencies of occurrence over the past 30 days were assessed. As a result, more than half (381, 56.2%) of the households were food secure and 297, 43.8%) were food insecure (figure 2).

Adolescent eating habit and frequency

The adolescents' eating habits were analyzed based on parents' reports on their adolescent's meal frequency; subsequently, 348 (52.2%) of the adolescents consumed meals three times per day, while 36.1 percent of the respondents did not eat meat once a week. while the vast majority of

adolescents (92.2%) eat Injera at home. Almost half of the students (45%) do not consume fruit on a weekly basis (table 3).

Table 3: Eating habit and frequency among adolescent in public schools of Addis Ababa, 2021

Variable	**Categorical**	**Frequency**	**Percentage**
Meal frequency	Once a day	12	1.8
	Twice a day	190	28
	Three times a day	323	47.6
	More than four times	152	22.6
Frequency of Meat eating in week	Never	134	19.8
	Once a week	166	24.5
	Twice a week	152	22.4
	Three times a week	117	17.5
	More than three times a week	109	16
Soft drinks in one week	Never	160	23.3
	Once a week	136	20.1
	Twice a week	180	26.5
	Three times a week	78	11.5
	More than three times a week	104	15.3
Drink citrus fruit, in week	Never	138	20.4
	Once a week	172	25.4
	Twice a week	256	37.8

	More than twice per week	112	16.5
Eating egg in week	Never	263	38.8
	Once a week	95	14
	More than Twice a week	175	28.5
	Every day	143	21.4
Drink Milk and milk products in week	Never	235	34.7
	Once a week	185	27.3
	More than twice a week	125	18.4
	Once a day	133	19.6
Staple food in the family	Injera	495	72.7
	Bread	154	22.7
	Other	31	4.5

Prevalence of stunting and thinness among adolescents in public schools

The overall prevalence of stunting and thinness among adolescents was [7.2 %(95%CI (5.3-9.3)] and [9 %(95%CI (6.8-11.4)] respectively (figure 3).

Factors associated with stunting among adolescents

The bivariate regression analysis indicated that sex, family size, mother's occupation, dietary diversity, household food insecurity, and wealth index were associated with stunting at a p value of less than 0.2. While, in multivariable analysis, family size, individual dietary diversity, household food insecurity, and wealth index were statistically and independently associated with stunting.

As a result, adolescents with a family size of more than five had an almost four-times higher risk of stunting than those with a family size of less than three [AOR = 3.764; 95% CI = (1.583-8.94)]. Similarly, participants who were food insecured at the household level were three times more likely to be stunted [AOR = 2.804: 95% CI = (1.378-5.706)]. Furthermore, the chances of

stunting were three times higher among participants having poor dietary diversity compared with their counterparts [AOR = 2.870; 95%CI (1.435-5.741)]. The odds of stunting were also higher among adolescent students from poor families (AOR=3.343 (1.510–7.403)) (table 4).

Table 4: *Bivariate and multivariable logistic regression analysis for stunting among adolescent students in Addis Ababa, 2021*

Categories	Stunted		COR(95%CI)	AOR(95%CI	P value
	Yes	No			
Sex					
Male	31(4.6%)	333(49.1%)	1.510(.282-2755)	1.316(.307-5.631)	.556
Female [rc]	18(2.7%)	296(43.4%)	1	1	
Family size					
<3[rc]	7(1%)	197(29.1%)	1	1	
4-5	9(1.3%)	208(30.7%)	1.862(.844- 4.106)	1.113 (.396-3.125)	.839
>5	33(4.9%)	224(33%)	2.759((1.32-5.75)	**3.764 (1.583-8.948)**	.003**
Mother occupation					
House wife	19(3%)	140(21.9%)	3.046(1.33-6.929)	1.358(.455-4.052)	.583
Daily laborer	6(0.9%)	73(11.4%)	1.845(.635-5.363)	.979(.252-4.128)	.977
Governmental	10(1.6%)	129(20.2%)	1.740(.688-4.398)	2.002(.583-6.876)	.270
Non-government	4(0.6%)	46(7.2%)	1.952(.576-6.614)	1.257(.190-8.312)	.813
Self-employ [rc]	9(1.4%)	202(31.7%)	1	1	
House hold food security status					
Food secure [rc]	12(1.8%0	369(54.4%)	1	1	
Food insecure	37(5.5%)	260(38.3%)	4.376(2.239-8.553)	**2.804 (1.378-5.706)**	.004**
Individual dietary diversity score					
Good dietary [rc]	13(1.9%)	376(55.5%)	1	1	

Poor dietary	36(5.3%)	253(37.3%)	4.116(2.14-7.914)	**2.870 (1.435-5.741)**	. 005**
Wealth Index					
Poor	31(4.5%)	200(29%)	3.978(1.850-8.557)	**3.343 (1.510-7.403)**	.001***
Middle	9(1.3%)	198(29.2%)	1.178(.454-2.998)	1.190 (.450-3.142)	.726
Wealthy	9(1.3%)	231(34.1%)	1	1	

Reference Category, Significant at P – Value of <0.5** Significant at P – Value of <0.01***

Factors associated with thinness among adolescent students

At bivariate analysis, for thinness, sex, family size, mother's occupation, father's occupation, mother's education, individual dietary diversity, household food security, and wealth index all had a p value less than 0.2. However, after adjusting for confounding factors, multivariable analysis revealed that family size, mother education, and individual dietary diversity were statistically and independently linked with thinness with a P-value less than 0.05.

Accordingly, adolescents from a family size of more than five were nearly 2.4 times more likely than those with a family size of less than three to acquire thinness [AOR=2.458, 95 percent CI: (1.140-5.296)].

Similarly, the odds of being thin were 3 times higher among participants whose mothers were not able to read and write compared with participants whose mothers had a college diploma and above [(AOR=2.59; 95%CI (1.969-8.003)]. Individuals with insufficient dietary diversity had a nearly five-fold higher risk of being thin than their peers [(AOR=4.812:95 percent CI (2.552–9.072)] (table 5).

Table 5: *Bivariate and multivariable analysis of the distribution of thinness among adolescents in public school students, Addis Ababa, 2021.*

Categories	**Thinness**		**COR(95%CI)**	**AOR(95%CI**	**P VALUE**
	Yes	**No**			
Sex					
Male	40(5.9%)	324(47.8%)	1.723(.993-2.989)	1.291(.675-2.77)	.439

Female	21(3.1%)	293(43.2%)	1	1	
Family size					
<3[rc]	10(1.5 %)	194(28.6%)	1	1	
4-5	19(2.8%)	198(29.2%)	1.862(.844-4.106)	1.607 (.707-3.64)	.257
>5	32(4.7%)	225(33.2%)	2.759((1.32-5.75)	**2.45 (1.140-5.29)**	.022**
Mother Education					
Unable to read and write	12(1.9%)	73(11.6%)	3.179(1.05-9.54)	**2.593(1.969-8.03)**	0.05**
Able to read and write	9(1.4%)	138(21.8%)	1.362(.473-3.923)	2.401 (.758-7.612)	.137
Primary education	15(2.4%)	152(24.1%)	1.501(.535-4.212)	2.377 (.765-7.380)	.134
Secondary education	16(2.5%)	117(18.5%)	1.131(.356-3.593)	2.387 (.342-7.706)	.146
College and above [rc]	5(0.8%)	95(15%)	1	1	
HHFS					
Food secure [rc]	22(3.2%)	359(52.9%)	1	1	
Food insecure	39(5.8%)	258(38.1%)	2.467(1.42-4.261)	1.430(.767-2.66)	.260
Individual dietary diversity					
Good dietary [rc]	15(2.2%)	374(55.2%)	1	1	
Poor dietary	46(6.8%)	243(35.8%)	4.720(2.578-8.64)	**4.812 (2.55-9.07)**	. 000***
Wealth Index					
Poor	26(3.8%)	205(30.2%)	1.664(.877-3.155)	1.398(.668-2.925)	.374
Middle	18(2.7%)	189(27.9%)	1.249(.626-2.492)	1.180(.523-2.660)	.691
Wealthy	17(2.5%)	223(32.9%)	1	1	

Reference Category, Significant at P – Value of <0.05** Significant at P – Value of <0.01**

Discussion

Overall, 7.2% of adolescent children in public schools in Addis Ababa, Ethiopia were stunted. When compared to a study report from Brazil (6%) (19) and Kenya (6.5%) (20), this result was higher. Differences in socioeconomical, cultural, and seasonal factors could explain the difference. However, this result was lower than those of research conducted in Adama, Ethiopia (21.3%) (21) and Ambo City, Ethiopia (27.5%) (22).This disparity could be explained by the disparity in income between the two research areas and study periods. Adolescents in Addis Ababa were more likely to have access to food, nutrition information, and educated households than those in Ambo and Adama City.

According to multivariable analysis at a p value of 0.05, family size, individual dietary diversity, household food insecurity, and wealth index were statistically and independently linked with stunting.

In terms of family size, school adolescents who lived in households with five members or more were nearly four times more likely to be stunted than school adolescents who lived in households with three members. A study conducted in Dale, southern Ethiopia; Adwa Town, northern Ethiopia; and Indonesia backed up the findings (23-25). This could be owing to the large number of family members sharing the limited food, resulting in insufficient food consumption and stunting. Furthermore, when family size increased, per capita human inputs declined, which could be explained by a larger dependency ratio, resulting in poorer nutritious consumption among adolescent students.

Adolescents with poor dietary diversity were three times more likely to be stunted than their counterparts. This finding was consistent with a report from Dangila, western Ethiopia; Rabat, Morocco; and India (26-28). This could be explained by the fact that in a phase of rapid growth and development, poor dietary diversity and irregular food intake are less likely to meet adolescents' nutritional requirements. As a result, failure to provide adequate food for daily body demand would result in stunting.

Household food insecurity was found to be significantly linked to stunting, with adolescents from food insecure families being roughly three times more likely to be stunted than those from food secure families. This finding was supported by data from Jimma, Southwest Ethiopia,

Somali Region, eastern Ethiopia, and a meta-analysis from developing-regions (29-31). The possible explanation for this could be high market and food inflation, which may have negatively impacted the food security situation of urban households, in addition to seasonal variations within and across countries. As a result, adolescents may have reduced food intake, consumed poor-quality diets, or disrupted eating patterns, which can ultimately lead to stunting.

Adolescents from poor families were three times more stunted than those from wealthy families. This conclusion was backed up by research conducted in the Gurage zone, Ethiopia (32), Axum, northern Ethiopia (33), and Bihar, India (34). This could imply that the nutritional status of teenagers is solely determined by the socioeconomic position of the households in which they live. This further results in insufficient dietary quality and quantity due to the inability to purchase a variety of foods and eating preferences. Furthermore, adolescents from low-income households may have less access to and utilization of health care than those from wealthy families.

Thinness was found to be prevalent in [9% (95% CI 6.8–11.4)] of the population. This finding was consistent with a study conducted in Debark, Northern Ethiopia, 10.3% (35) and yawned, Cameroon reported 9.5% (36). However, it was lower than studies in Mekelle City, northern Ethiopia, 26.1% (37), Western Kenya, 15.6% (38), and India, 20% (39). This gap could be attributable to the implementation of nutrition intervention programs in Addis Ababa public schools by state and nongovernmental organizations. Furthermore, cultural differences and socioeconomic disparities may have a role.

The odds of being skinny were 2.5 times greater among participants whose mothers couldn't read or write compared to participants whose mothers had a college diploma or higher educational standing. This result was similar to those found in Adwa, Ethiopia (40), Assam, India (32) and Adama, Ethiopia (41). This could be due to the mother's low level of education, a lack of nutrition knowledge, or the fact that they are not formally educated and cannot understand different promotions. As a result, her decision-making ability and contribution to the total family income will be limited. It could also have an impact on the type of food that is made and supplied.

Adolescents from households with more than five individuals were 2.4 times thinner than those from households with fewer than three members. Adwa town in North Ethiopia (42) and Riyadh, Saudi Arabia (43) have both reported similar occurrences. This could be due to the numerous household members sharing the available food and increased competition for food, which could impair both the quality and amount of food served at home, resulting in insufficient food consumption and thinness.

When it came to dietary diversity, adolescents with inadequate dietary diversity were 4.8 times thinner than those with strong dietary diversity. This result was similar to those reported in Karnataka, India (23) and Axum, Ethiopia (24). This could be attributed to a lack of nutritional diversification and irregular meals.

Limitation

The current study is cross-sectional in design, which does not establish a causal relationship between the outcome variable and independent factors. In addition, it might be affected by recall bias.

Conclusion and recommendation

In the research area, adolescent stunting and thinness were most common. Moreover, parental education, family size, and individual dietary diversity were all linked to being thin. Stunting was also associated with household income index, family size, food insecurity, and individual dietary diversity. Therefore, to decrease adolescent malnutrition, a concerted effort at all levels should be made to promote maternal education, household food security, and nutritional diversity.

Declaration

Ethical consideration

The researchers secured ethical approval from Kotebe University of Education, Menelik II Medical and Health Science College research and ethical review board with reference number ID KUE/38/12/3027. Official letters were obtained from the Addis Ababa health bureau, and an authorization letter was provided by the Lideta sub-city educational office. Following a thorough explanation of the study objectives to the adolescent parents or legal guardians, the data of the adolescent students was collected after having their informed written consent.

The author's contribution

Not applicable

Consent for publication

Not applicable

Data Availability

The datasets used to support the findings of this study are attached with the manuscript.

Conflicts of interest

The author declares they have no competing conflicts of interest.

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Author contributions

- ***AA:*** This author helped on substantial intellectual contributions to conception, design, and acquisition of data, analysis, and interpretation of data as well as on preparing the manuscript to this study.
- ***EA:*** have made substantial contributions to conception, design, and acquisition of data, analysis, and interpretation of data as well as on preparing the manuscript to this study.
- ***TS:*** This author contributed to conception, design, analysis and

interpretation of data and give approval of the final version to be published.

- ***GK:*** has been involved in analysis, interpretation of data and drafting the manuscript and revising it critically for important intellectual contents.

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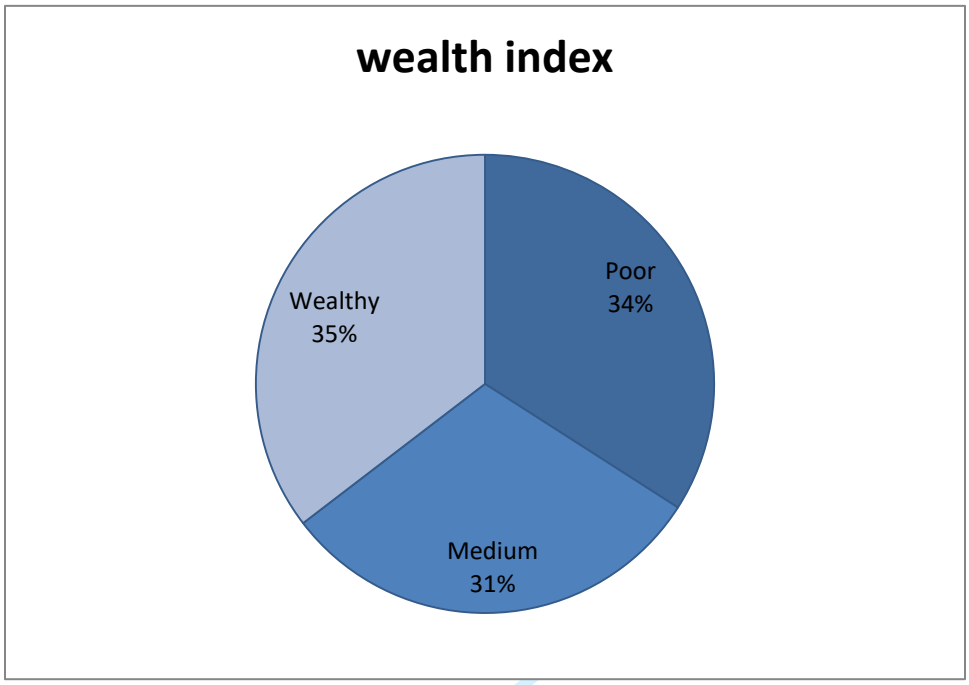

Figure1: wealth index among study participant adolescent households in Addis Ababa, 2021

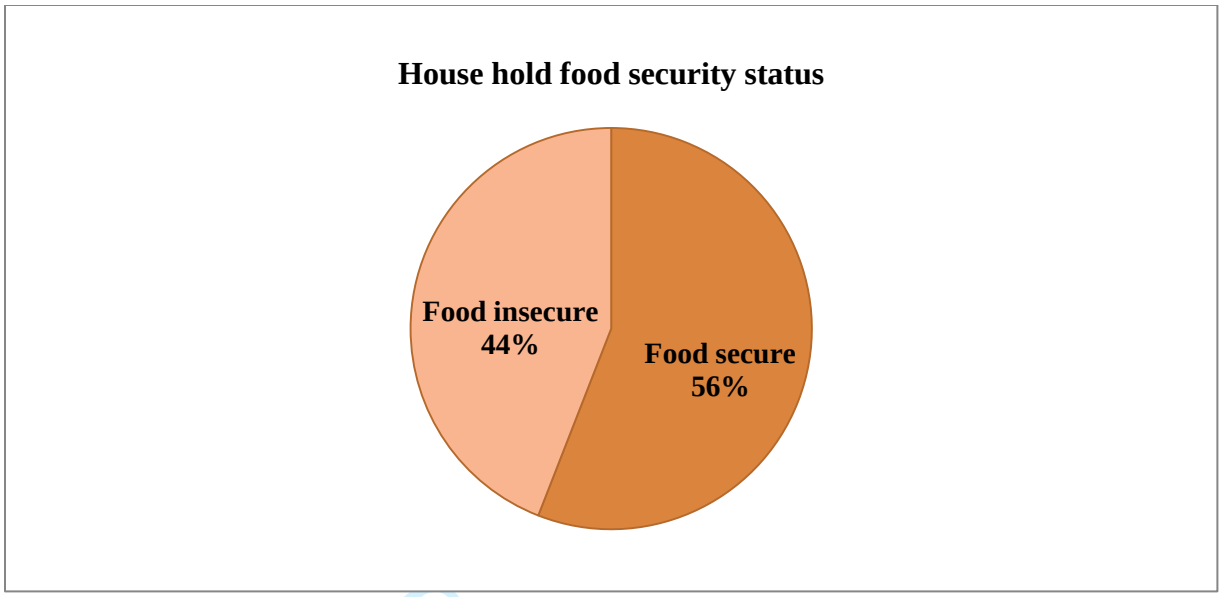

Figure 2: The food security status of an adolescent in a public school in Addis Ababa, Ethiopia, in 2021

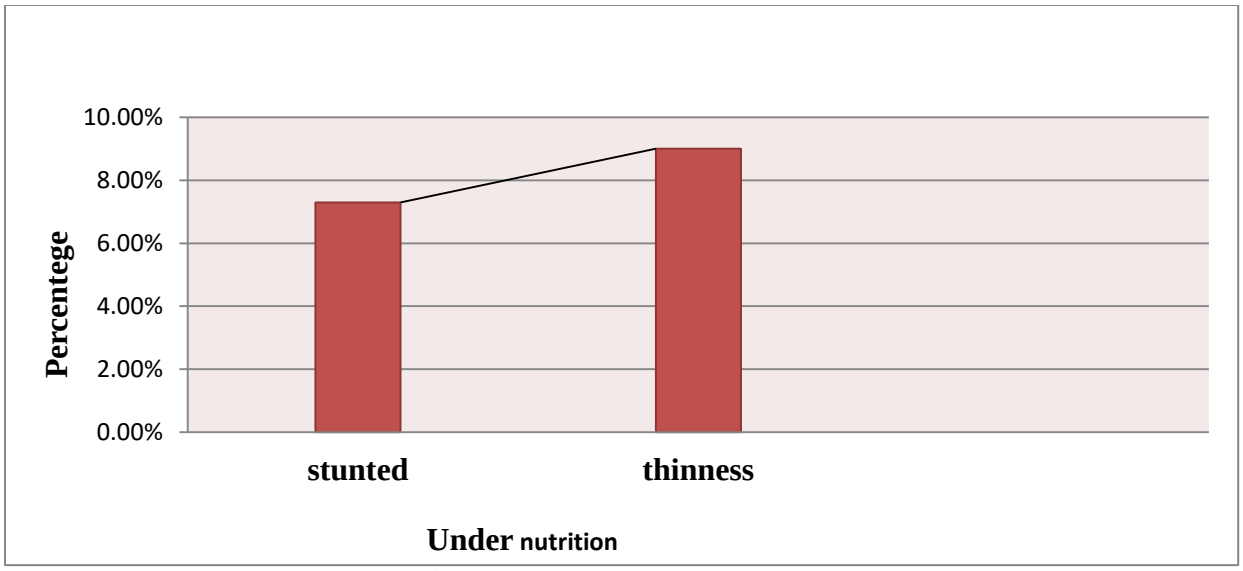

Figure 3: adolescent undernutrition status among adolescent students in public schools of Addis Ababa, 2021

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Prevalence and correlates of stunting and thinness among adolescents enrolled in public schools in Lideta sub-city, Addis Ababa, Ethiopia a cross-sectional study

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Abstract

Objectives: To determine the prevalence of stunting and thinness and associated factors among adolescents attending public schools in Lideta sub-city, Addis Ababa, Ethiopia, 2021.

Design: Cross-sectional

Setting: Public schools of Lideta sub-city, Addis Ababa, Ethiopia

Eligibility: Adolescents from grade 5–12 in the public schools and students whose parents gave consent for participation.

Data analysis: Bivariate and multivariable logistic regression analysis were used to examine the association between the independent variables and stunting and thinness. Using a 95% confidence interval (CI) and adjusted odds ratio (AOR), factors with a p-value of less than 0.05 were determined to have a significant association.

Outcome measures: Primary outcomes was the prevalence of stunting and thinness. Secondary outcomes were identifying the associated factors of stunting and thinness.

Results: The overall, prevalence of stunting and thinness was 7.2%: 95% CI (5.3–9.3%) and 9%:95% CI (6.8–11.4%) respectively. Stunting was associated with larger family size AOR = 3.76: 95% CI (1.58-8.94), low dietary diversity AOR = 2.87: 95% CI (1.44-5.74), food insecurity AOR = 2.81: 95% CI (1.38-5.71), and lower wealth index AOR = 3.34: 95% CI (1.51-7.41). While thinness was associated with maternal education who were unable to read and write AOR = 2.5: 95% CI (1.97- 8.01), inadequate dietary diversity AOR = 4.81: 95% CI (2.55-9.07), and larger family size AOR = 2.46: 95.0% CI (1.14-5.29).

Conclusion: Adolescent stunting and thinness were common in Addis Ababa public schools. Family size, dietary diversity, and food security were the main factors associated with both thinness and stunting. Therefore, to decrease adolescent undernutrition, the government of Addis Ababa city administration should prioritize minimizing food insecurity while boosting productivity to enhance adolescent nutritional diversity. Moreover, nutrition and contraceptive education should be strengthened by healthcare providers working at public schools and health extension workers.

Keywords: stunting, thinness, undernutrition, adolescence, public schools, Ethiopia

Strength and limitation of the study

- The study had a larger sample size (678) and a maximum response rate (100%).
- The study used a cross-sectional study design, which does not establish a causal relationship between the outcome variable and independent factors.
- The finding of this study might be affected by recall and social desirability bias.

Introduction

According to the World Health Organization (WHO), adolescence is defined as the period from 10 to 19 years during which an individual undergoes major physical growth, mental development, and psychological changes (1, 2). There are nearly 1.3 billion adolescents worldwide, accounting for 16% of the global population (3). Particularly in Ethiopia, children and adolescents make up around 48% of the overall population (4). Adolescents gain up to 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeletal mass as a result of increased dietary needs (5).

Suboptimal nutrition during this period leads to a triple burden of undernutrition, with consequences for their health and sexual development (6). In low- and middle-income countries, malnutrition, particularly undernutrition, is very common among adolescents (7, 8). In a study that examined the global trend in 24.1 million children's nutritional status between the ages of 5 and 17 years, it was shown that the prevalence of underweight had decreased in all but South Asia, Central Africa, East Africa, and West Africa (9). Since both under- and overnutrition coexist in the majority of sub-Saharan African countries, including Ethiopia, they are facing a phenomenon called the “double burden of malnutrition” (10). Moreover, the prevalence of stunting and thinness in developing nations among adolescents ranges from 32 to 48% (11, 12), particularly in Ethiopia, where it was reported to be 7.2 to 26.5% (13).

Malnutrition, in all its forms, includes overnutrition (overweight, obesity), undernutrition (wasting, stunting, underweight), and inadequate vitamins or minerals (14). Undernutrition in adolescence manifests as stunting and thinness, which have the potential to reduce learning capacity, delay sexual maturation, cause inattentiveness, impede academic performance, weaken physical and economic progress, restrict the body's capacity to absorb nutrients properly, and prolong poverty (15-17).

Undernutrition in adolescents is best measured by two major indicators: the low BMI (body mass index) for age, which is less than two standard deviations (SD), and stunting, which is the low height for age, which is less than two SD (18). Adolescents' nutritional status is affected by a variety of circumstances. The key determinants are socioeconomic status, age, sex, household income, marital status, family size, maternal education, food insecurity, dietary diversity, patterns, and habits (19, 20).

Undernutrition during the adolescent period diminishes the working capacity of an individual during adulthood (21, 22). Ultimately, it silently destroys the future socio-economic development of a nation and even causes the cruel cycle of intergenerational undernutrition by causing parents to share the consequences with their children, including low birth weight, short stature, and low resistance to infection (23-25). This problem would be devastating in Ethiopia, where about 27.7% of adolescent girls become pregnant at the age of nineteen (26).

Ethiopia has been working to reduce the high burden of undernutrition through the implementation of national programs like the National Nutrition Program (NNP), including school feeding, for the past three years in Addis Ababa. As far as our knowledge is concerned, this is the first study since the start of the public-school feeding program. Therefore, the study aims to assess stunting, thinness, and associated factors among adolescents in Lideta, a sub-city of Addis Ababa, Ethiopia, in 2021.

Methods

Study area and period: The study was conducted in the Lideta sub-city of Addis Ababa, Ethiopia. The Lideta sub-city is one of the eleven sub-cities of Addis Ababa city administration, located in the central part of the town. Information obtained from the Lideta sub-city educational office reported that there were eighteen primary schools and three secondary schools. In the academic year 2020-2021, around 10,033 adolescents were registered. Of these, 3,431 were in secondary schools, and the remaining were in primary schools.

In Addis Ababa, a large-scale SFP (School Feeding Program) was launched in February 2019 with the goal of feeding kids in public elementary schools to reduce hunger in the classroom. The education bureau of Addis Ababa municipal administration owns and funds the Addis Ababa SFP,

which provides two meals for students each day (breakfast and lunch each school day). The food menu states that throughout the course of a week, a total of eleven different food types and items are served for both breakfast and lunch. The school lunch consists of rice, bread, marmalade, shiro-based, fir fir, potato-based sauce, white bread (difo), injera, refined bread, tea, and boiled eggs. All of the public elementary schools in Addis Ababa provide identical school lunches (27). The study was conducted from May 20th to June 5th, 2021 using an institution-based cross-sectional study design.

Source population: All adolescent students in public schools enrolled in Lideta sub-city, Addis Ababa, Ethiopia.

Study population: All school adolescents enrolled within randomly selected primary and secondary schools of Lideta Sub-city, Addis Ababa, Ethiopia.

Eligibility criteria

Inclusion criteria

Adolescents from grades 5–12 in the selected public schools and students whose parents gave consent participated in the study.

Exclusion criteria

Those public-school adolescents who were seriously ill and absent for any reason during the data collection period were excluded from the study.

Sample size determination and sampling procedure

The sample size was calculated using the single population proportion formula.

$$n = \frac{(Z\frac{\alpha}{2})^2 P(1-P)}{d^2}$$

The magnitude of stunting and thinness from the previous studies was considered 20.7 and 22% (17, 28), with a precision of 4%, a 95% confidence interval, a design effect of 1.5, and adding a 10% non-response rate, the maximum sample size was 678.

For this study, seven primary and two secondary schools were selected using simple random sampling techniques among the eighteen primary and three secondary schools that were available

in the Lideta sub-city. Each school and class (grades 5–12) found in each selected school received a proportional allocation of the sample size. Each school's administrators provided a sampling frame (a list of adolescents aged 10–19 years). Finally, a simple random sample strategy was utilized to pick study participants by using the student list as a sampling frame.

Study variables

Dependent variables

Thinness and stunting

Independent variables

Sociodemographic characteristics include age, wealth index, family size, parents' education, wealth index, dietary diversity, etc.

Anthropometry measurements: weight, height,

Environmental factors: toilet, hand washing,

Data collection methods and procedures: four diploma nurses and two BSC health officers were hired as data collectors and supervisors, respectively. Data was collected through a face-to-face interview using a structured and pre-tested questionnaire.

The data collection began with the permission and consent of student parents at their residence. The parents were quizzed on sociodemographic factors, food security, wealth index, environmental sanitation, and hygiene in their home. Questionnaire-administered interviews with all of the parents (mothers or fathers) of students below 19 years were conducted at their homes in the afternoon as soon as the children arrived home. The remaining individual dietary information was obtained from the adolescent.

The questionnaire for this study was adopted from the EDHS (Ethiopian Demographic Health Survey) (19) and reviewed in the literature of similar studies (7, 8, 18). The tool contains sociodemographic, nutritional, environmental, and dietary factors.

Height measurement

Setting up the measurement site

The height was measured with a stadiometer applied vertically to a hard, flat wall surface with the base at floor level. The vertical location of the rule was checked with a carpenter's level. In the absence of such a floor, a hard wooden platform was placed beneath the height base.

Setting up the measurement site

It was measured by a weighting scale (model 8811021659, made in Germany). The weighing balance was calibrated in kilograms, and students were weighed to the nearest 0.1 kg while dressed in light clothing and without shoes.

Measuring the dietary diversity score (DDS)

The DDS was used to assess nutritional adequacy, which was defined as the number of food categories ingested in a certain period of time, often 24 hours. Each respondent was questioned about the food they had eaten the previous day, both at home and away from it. among those who consumed at least 4 different food groups the day before, obtained as minimal dietary diversity (MDD) from 8 different food categories (24-hour recall). The DDS of eight food categories (grains (white roots, tubers, and plantains), pulses (beans, peas, and lentils), nuts and seeds, dairy and eggs, dark green leafy vegetables, vitamin-A-rich fruits and vegetables, vegetables, and fruits) was used, and it was calculated by taking into account the type and number of food groups consumed by the households (23). Poor dietary diversity was defined as the dietary diversity score below the median value (less than 4 food groups), and good dietary diversity was categorized as adolescents who had a dietary diversity score at or above the median value (greater than or equal to 4 food groups) (28).

Measuring food insecurity in households

The household food insecurity access scale (HFIAS) developed by FANTA was used to determine the level of food insecurity in the household. The scale explores the occurrence and frequency of occurrence of nine food insecurity-related events in the past 30 days of the survey. The household was classified as either food secure or food insecure by the HFIAS (29).

The wealth index procedure

Questions from the Ethiopian demographic and health survey, 2016, were used to determine the wealth level of the households (19). Fourteen major variables (mobile phone, radio, chairs, tables, television, watch, jewelry, car, motorcycle, house, non-mobile telephone, refrigerator, bed with cotton/sponge/spring mattress, and computer) were analyzed. The values of each wealth variable

were recoded as 0 and 1 before undertaking principal component analysis. Scores are assigned to households based on the number and types of consumer goods they own, including each durable good, from a television to a bicycle or car, as well as dwelling qualities like bathroom amenities and flooring materials. With the help of principal component analysis, these scores were created. By giving each household member a score, rating each household member according to that score, and then splitting the distribution into three equal groups, each of which includes 33% of the population, the wealth quintiles were created. Following that, principal component analysis was used to rank the findings from lowest to highest into three groups: poor, medium, and wealthy, which were coded as 1, 2, and 3, respectively.

Operational Definition:

Thinness was taken as a BMI for age (BAZ) value of less than two standard deviations from the WHO Child Growth Standard (30).

Stunting was defined as a height for age (HAZ) value of less than two standard deviations from the WHO Child Growth Standard (30).

Poor dietary diversity: adolescents with a dietary diversity score below the median value of less than 4 food groups (24).

Good dietary diversity: Adolescents were measured using a qualitative recall of all foods consumed by each adolescent during the previous 24 hours through a standardized and validated tool containing 8 food groups taken from verbal reports of the participants, and we considered an adolescent to have adequate dietary diversity if they reported consuming four or more food groups (11).

A food-secure household: A household with a score of 0–1 on the Household Food Insecurity Access Scale (HFIAS) is classified as food-secure (30).

Food insecure households: Based on an HFIAS score (0–27) of 2 and above, they were considered food insecure (31).

Quality assurance

In order to maintain the quality of the data, training was provided to data collectors and supervisors for one day by the principal investigators. The questionnaire was prepared first in English and then translated to the local language, Amharic, and back to English to check its consistency. A pretest was conducted on 5% of the subjects at Addis Ketema sub-city public schools, and the scales were

carefully handled and periodically calibrated by placing standard calibration weights of 2 kg iron bars on the scales. On-site supervision was performed, and each copy of the questionnaire was checked for completeness and accuracy before data entry.

Data processing and analysis

For cleaning, recoding, and categorizing variables, the collected data was entered into EPI Info 3.1 computer programs and exported to the Statistical Package for Social Sciences (SPSS) version 21 for analysis. In addition, WHO Anthro-Plus software was used to enter and analyze anthropometric data. PCA (principal component analysis) was used to examine the household wealth index. The Keiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to verify the statistical assumptions of factor analysis. As a result, a KMO of 0.5 or above, as well as a significant Bartlett's test of sphericity (p-value of 0.05), were deemed sufficient to satisfy the assumption.

Moreover, communality values and eigenvalues of 0.5 and greater than 1 were included in the factor analysis. The variables with less than 0.5 of the communality value were removed from the analysis, and the analysis was done repeatedly until all variables met the inclusion criteria for factor analysis. Next, all eligible factor scores were computed using the regression-based method to generate one variable, wealth status. Then, afterward, the loading factors were sorted in ascending order. Following this, the final scores were ranked into three quartiles, namely first, second, and third. Finally, ranks were interpreted as poor, medium, and wealthy, respectively. A descriptive summary (frequency distribution, proportion, mean, and standard deviation) was used to summarize the variable.

Binary logistic regression analysis was used to ascertain the association between explanatory and outcome variables. A variable whose p-value was less than 0.2 in the bivariate analysis was entered into the multivariable logistic regression analysis to determine factors associated with stunting and thinness. In the multivariable analysis, a p-value of less than 0.05 and an odds ratio with 95% CI were used to declare the presence and strength of association.

Patient and public involvement

Throughout the data collection period parents or the legal guardians of the study participants and public-school teachers were involved with a free support and advice for the researchers related

with ethical issues and advice on how to share our findings to a wide audience, in a way the public can understand.

Results

Socio-demographic characteristics of adolescents and their families

A total of 678 adolescent students were included in the study with a 100% respondent rate. Males made up nearly half (364, or 53.7%) of the study participants. The average age of the respondents was 15 (SD 2.4) years, with a range of 11 to 19 years. Almost one third (211, or 31.6%) of the study participants were early adolescents. The majority of participants (446, or 65.8%) were from primary schools. In terms of their parents' occupation status, nearly a quarter (173 or 25.5%) of their fathers and 158 (23.3%) of their moms were government employed and housewives, respectively (Table 1).

Table 1: Sociodemographic characteristics of the study participants among adolescent students in a public school in Lideta sub-city, Addis Ababa, Ethiopia (n = 678)

Variables	Category	Frequency	Percent (%)
Sex	Male	364	53.7
	Female	314	46.3
Adolescent age	10-13	219	32.3
	14-16	296	43.7
	17-19	163	24
Adolescent grade	Primary school	446	65.8
	Secondary school	231	34.1
Fathers' educational status	Unable to read and write	77	11.4
	Able to read and write	233	34.4

	Primary education	147	21.7
	Secondary education	106	15.6
	College and above	84	12.4
Mother's education	Unable to read and write	85	12.5
	Able to read and write	147	21.7
	Primary education	167	24.6
	Secondary education	100	14.8
	College and above	80	11.8
Family size	<3	204	30.1
	4-5	217	32
	>5	257	37.9
School feeding	Yes	446	65.8
	No	232	34.2

*Primary school consists of grades five to eight, and *secondary school includes grades nine to twelve.

The dietary diversity status of adolescents

The mean (SD) dietary diversity score in the study group was 4.2 (2). The proportion of adolescents who consumed good dietary diversity was 389 (57.4%) and the proportion of adolescents who consumed poor dietary diversity was 289 (42.6%). The greater proportion of 594 (90.4%) of the study participants consumed food containing cereals, while only 187 (28%) of respondents reported consuming animal products (table 2).

Table 2: Dietary diversity among adolescents in public schools of Lideta sub-city, Addis Ababa, Ethiopia 2021

Variable	Response	Frequency	Percentage
Grains, Root or Tuber	Yes	597	88.1
	No	81	11.9
Vitamin A rich fruit and vegetable.	Yes	401	59.1
	No	277	40.9
Fruits and Vegetables	Yes	350	48.4
	No	328	51.6
Meat, poultry, offal and Fish	Yes	193	28.5
	No	485	71.5
Eggs (eggs)	Yes	199	70.6
	No	479	29.4
Pulses, Legumes, nuts and seeds	Yes	257	37.9
	No	421	62.1
Milk& milk products	Yes	296	43.7
	No	382	56.3

Food cooked Oils and Fats	Yes	532	78.5
	No	146	21.5

*Vitamin A-rich fruits and vegetables include red, yellow, and green leafy vegetables like carrots, cabbage, sweet potatoes, mango, and papaya.

Wealth index and food security status of households

Regarding household food security measurement, the study participants were asked to report the frequency of worrying about what to eat and the range of remaining hunger day and night in the previous four weeks before the survey. Based on the nine HFIAS questions' responses, their frequencies of occurrence over the past 30 days were assessed. As a result, more than half (381, or 56.2%) of the households were food secure, and 297, or 43.8 percent, were food insecure.

Moreover, according to wealth classification, 231 (34.1%) of households had poor assets, while 207 (30.5%) and 240 (35.4%) were classified as medium-asset and rich-asset households, respectively.

Adolescent eating habits and frequency

The adolescents' eating habits were analyzed based on adolescent and their parents' reports on their meal frequency; subsequently, 348 (52.2%) of the adolescents consumed meals three times per day, while 36.1% of the respondents did not eat meat once a week. while the vast majority of adolescents (92.2%) eat injera at home. Almost half of the students (45%) do not consume fruit on a weekly basis (table 3).

Table 3: Eating habits and frequency among adolescents in public schools of Lideta sub-city, Addis Ababa, 202

Variable	**Category**	**Frequency**	**Percentage**
Meal frequency	Once a day	12	1.8
	Twice a day	190	28
	Three times a day	323	47.6
	More than four times	152	22.6
Frequency of meat eating in week	Never	134	19.8

	Once a week	166	24.5
	Twice a week	152	22.4
	Three times a week	117	17.5
	More than three times a week	109	16
Soft drinks in one week	Never	160	23.3
	Once a week	136	20.1
	Twice a week	180	26.5
	Three times a week	78	11.5
	More than three times a week	104	15.3
Drink citrus fruit, in week	Never	138	20.4
	Once a week	172	25.4
	Twice a week	256	37.8
	More than twice per week	112	16.5
Eating egg in week	Never	263	38.8
	Once a week	95	14
	More than twice a week	175	28.5
	Every day	143	21.4
Drink Milk and milk products in week	Never	235	34.7
	Once a week	185	27.3
	More than twice a week	125	18.4
	Once a day	133	19.6
Staple food in the family	Injera	495	72.7
	Bread	154	22.7

	Other	31	4.5

Prevalence of stunting and thinness among adolescents in public schools

The overall prevalence of stunting and thinness among adolescents was 49 (7.2%) (95%CI (5.3-9.3%) and 61 (9%) (95%CI (6.8-11.4%) respectively (figure 1). Thinness was more common among adolescents aged 17–19 years (11%), compared with age groups 14–16 years (8.8%) and 10–13 years (7.8%). Similarly, stunting was more prevalent among 17-19 years of adolescents 9.8% whereas it was 8.2 and 5.1% among 10-13 and 14-16 years respectively. Besides, thinness was more than two times as common and stunting was nearly four times as prevalent among school-age adolescents from food-insecure households compared with their counterparts, and the proportions of thinness and stunting among adolescents who had poor dietary diversity were 15.9 and 12.5%, respectively. Based on sex category both thinness and stunting were higher among males 11% and 8.5% respectively compared with females (table 4).

Table 4: Proportion of thinness and stunting in relation to different variables

Variables	**Thinness**		**Stunting**	
	Yes	**No**	**Yes**	**No**
Sex				
Male	40(11%)	324(89%)	31(8.5%)	333(91.5%)
Female	21(6.7%)	293(93.3%)	18(5.7%)	296(94.3%)
Age group				
10-13	17(7.8%)	202(92.2%)	18(8.2%)	201(91.8%)
14-16	26(8.8%)	270(91.2%)	15(5.1%)	281(94.9%)
17-19	18(11.0%)	145(89.0%)	16(9.8%)	147(90.2%)
Food security				
Secured	22(5.8%)	359(94.2%)	12(3.1%)	369(96.9%)

Insecured	39(13.1%)	258(86.9%)	37(12.5%)	260(87.5%)
Wealth index				
Poor	26(11.3%)	205(88.7%)	31(13.4%)	200(86.6%)
Middle	18(8.7%)	189(91.3%)	9(4.3%)	198(95.7%)
Wealthy	17(7.1%)	223(92.9%)	9(3.8%)	231(96.2%)
Dietary diversity				
Good	15(3.9%)	374(96.1%)	13(3.3%)	376(96.7%)
Poor	46(15.9%)	243(84.1%)	36(12.5%)	253(87.5%)

Factors associated with stunting among adolescents

The bivariate regression analysis indicated that sex, family size, the mother's occupation, dietary diversity, household food insecurity, and wealth index were associated with stunting. While, in multivariable analysis, family size, individual dietary diversity, household food insecurity, and wealth index were statistically and independently associated with stunting.

Adolescents with a family size of more than five had nearly four-times higher risk of stunting than those with a family size of less than three [AOR = 3.764; 95% CI = (1.583-8.94)]. Similarly, participants who were food insecure at the household level were three times more likely to be stunted [AOR = 2.804; 95% CI = (1.378–5.706)]. Furthermore, the chances of stunting were three times higher among participants with poor dietary diversity compared with their counterparts [AOR = 2.870; 95% CI (1.435-5.741)]. The odds of stunting were also higher among adolescent students from poor families [AOR = 3.343; 95% CI (1.510–7.403)] (table 5).

Table 5: Bivariate and multivariable logistic regression analysis for stunting among adolescent students in Lideta sub-city, Addis Ababa, 202

Variables	**Stunted**		**COR (95%CI)**	**AOR (95%CI**	**P-value**
	Yes	**No**			

Sex					
Male	31 (4.6%)	333 (49.1%)	1.51 (.282-2755)	1.316 (.307-5.631)	.556
Female	18 (2.7%)	296 (43.4%)	1	1	
Family size					
<3	7 (1%)	197 (29.1%)	1	1	
4-5	9 (1.3%)	208 (30.7%)	1.862 (.844- 4.106)	1.113 (.396-3.125)	.839
>5	33 (4.9%)	224 (33%)	2.759 ((1.32-5.75)	**3.764 (1.583-8.948)**	.003**
Mother occupation					
House wife	19 (3%)	140 (21.9%)	3.046 (1.33-6.929)	1.358 (.455-4.052)	.583
Daily laborer	6 (0.9%)	73 (11.4%)	1.845 (.635-5.363)	.979 (.252-4.128)	.977
Governmental	10 (1.6%)	129 (20.2%)	1.740 (.688-4.398)	2.002 (.583-6.876)	.270
Non-government	4 (0.6%)	46 (7.2%)	1.952 (.576-6.614)	1.257 (.190-8.312)	.813
Self-employ	9 (1.4%)	202 (31.7%)	1	1	
House hold food security status					
Food secure	12 (1.8%)	369 (54.4%)	1	1	
Food insecure	37 (5.5%)	260 (38.3%)	4.376 (2.239-8.553)	**2.804 (1.378-5.706)**	.004**
Individual dietary diversity score					
Good dietary	13 (1.9%)	376 (55.5%)	1	1	
Poor dietary	36 (5.3%)	253 (37.3%)	4.116 (2.14-7.914)	**2.870 (1.435-5.741)**	. 005**
Wealth Index					
Poor	31 (4.5%)	200 (29%)	3.978 (1.850-8.557)	**3.343 (1.510-7.403)**	.001**
Middle	9 (1.3%)	198 (29.2%)	1.178 (.454-2.998)	1.190 (.450-3.142)	.726
Wealthy	9 (1.3%)	231 (34.1%)	1	1	

Reference category: significant at a p–value of <0.05*, significant at a p–value of <0.01**

Factors associated with thinness among adolescent students

Bivariate study revealed that sex, family size, mother's education, father's career, individual dietary diversity, household food security, and wealth index were all related to thinness. Multivariable analysis, however, showed that family size, mother education, and individual dietary diversity were statistically and independently related with thinness after controlling for confounding variables. Accordingly, adolescents from a family size of more than five were nearly 2.4 times more likely than those with a family size of less than three to acquire thinness [AOR=2.458, 95 percent CI: (1.140-5.296)].

Similarly, the odds of being thin were three times higher among participants whose mothers were not able to read and write compared with participants whose mothers had a college diploma and above [AOR = 2.59; 95% CI (1.969–8.003)]. Individuals with insufficient dietary diversity had a nearly five-fold higher risk of being thin than their peers [(AOR=4.812:95 percent CI (2.552–9.072)] (table 6).

Table 6: Bivariate and multivariable analysis of thinness among adolescents in public school students of Lideta sub city, Addis Ababa, 2021.

Variables	Thinness		COR (95%CI)	AOR (95%CI	P-VALUE
	Yes	No			
Sex					
Male	40(5.9%)	324(47.8%)	1.723(.993-2.989)	1.291(.675-2.77)	.439
Female	21(3.1%)	293(43.2%)	1	1	
Family size					
<3rc	10(1.5 %)	194(28.6%)	1	1	
4-5	19(2.8%)	198(29.2%)	1.862(.844-4.106)	1.607 (.707-3.64)	.257
>5	32(4.7%)	225(33.2%)	2.759((1.32-5.75)	**2.45 (1.140-5.29)**	.022*
Mother Education					

Unable to read and write	12(1.9%)	73(11.6%)	3.179(1.05-9.54)	**2.593(1.969-8.03)**	0.05*
Able to read and write	9(1.4%)	138(21.8%)	1.362(.473-3.923)	2.401 (.758-7.612)	.137
Primary education	15(2.4%)	152(24.1%)	1.501(.535-4.212)	2.377 (.765-7.380)	.134
Secondary education	16(2.5%)	117(18.5%)	1.131(.356-3.593)	2.387 (.342-7.706)	.146
College and above	5(0.8%)	95(15%)	1	1	
HHFS					
Food secure	22(3.2%)	359(52.9%)	1	1	
Food insecure	39(5.8%)	258(38.1%)	2.467(1.42-4.261)	1.430(.767-2.66)	.260
Individual dietary diversity					
Good dietary	15(2.2%)	374(55.2%)	1	1	
Poor dietary	46(6.8%)	243(35.8%)	4.720(2.578-8.64)	**4.812 (2.55-9.07)**	. 001**
Wealth Index					
Poor	26(3.8%)	205(30.2%)	1.664(.877-3.155)	1.398(.668-2.925)	.374
Middle	18(2.7%)	189(27.9%)	1.249(.626-2.492)	1.180(.523-2.660)	.691
Wealthy	17(2.5%)	223(32.9%)	1	1	

Reference category: significant at p–value of <0.05*, significant at p–value of <0.01**

Discussion

The current study findings revealed that the prevalence of stunting and thinness was higher in male and older adolescents than in younger ones. The results were consistent with those of another study done in southern and central Ethiopia (32, 33). The possible explanation for the reason behind this might be due to the fact that those young adolescents participate in the school lunch program. Overall, 7.2% of adolescents in public schools in Lideta, a sub-city of Addis Ababa, were stunted. When compared to a study report from Brazil (6%) (34) and Kenya (6.5%) (35), this result was

higher. Differences in socioeconomical, cultural, and seasonal factors could explain the difference. However, this result was lower than those of research conducted in Damot Sore District, Southern Ethiopia (29.6%) (32) and in Adama City, Central Ethiopia (21.3%) (33). This disparity could be explained by a difference in income between the two research areas and study periods. Adolescents in Addis Ababa were more likely to have access to food, nutrition information, and educated households than those in Ambo and Adama City. Moreover, there is a school feeding program in Addis Ababa since 2019.

School adolescents who lived in households with five members or more were nearly four times more likely to be stunted than school adolescents who lived in households with three members. A study conducted in Dale, southern Ethiopia; Axum Town, northern Ethiopia; and Indonesia backed up the findings (35-37). This could be owing to the large number of family members sharing the limited food, resulting in insufficient food consumption and stunting. Furthermore, when family size increased, per capita human inputs declined, which could be explained by a larger dependency ratio, resulting in poorer nutritious consumption among adolescent students.

Adolescents with poor dietary diversity were three times more likely to be stunted than their counterparts. This finding was consistent with a report from Dangila, western Ethiopia; Rabat, Morocco; and India (22, 38, 39). This could be explained by the fact that, in a phase of rapid growth and development, poor dietary diversity and irregular food intake are less likely to meet adolescents' nutritional requirements. As a result, failure to provide adequate food for daily body demand would result in stunting.

Household food insecurity was found to be significantly linked to stunting, with adolescents from food-insecure families were roughly three times more likely to have stunting than those from food-secure families. This finding was supported by data from Jimma, Southwest Ethiopia, the Somali Region, eastern Ethiopia, and a meta-analysis from developing regions (21, 40, 41). The possible explanation for this could be high market and food inflation, which may have negatively impacted the food security situation of urban households, in addition to seasonal variations within and across countries. As a result, adolescents may have reduced food intake, consumed poor-quality diets, or disrupted eating patterns, which can ultimately lead to stunting.

Adolescents from poor families were three times more stunted than those from wealthy families. This conclusion was backed up by research conducted in the Gurage zone, Ethiopia (42), Axum,

northern Ethiopia (36), and Bihar, India (25). This could imply that the nutritional status of teenagers is solely determined by the socioeconomic position of the households in which they live. This further results in insufficient dietary quality and quantity due to the inability to purchase a variety of foods and eating preferences. Furthermore, adolescents from low-income households may have less access to and utilization of health care than those from wealthy families.

Thinness was found to be prevalent in 9% of the study populations. This finding was consistent with a study conducted in Debark, Northern Ethiopia, 10.3% (43) and yawned, Cameroon reported 9.5% (44). However, it was lower than studies in Mekelle City, northern Ethiopia, 26.1% (14), Western Kenya, 15.6% (45), and India, 20% (46). This gap could be attributable to the implementation of nutrition intervention programs in Addis Ababa public schools by state and nongovernmental organizations. Furthermore, cultural differences and socioeconomic disparities may play a role.

The odds of being skinny were 2.5 times greater among participants whose mothers couldn't read or write compared to participants whose mothers had a college diploma or higher educational standing. This result was similar to those found in Adwa, Ethiopia (47), Assam, India (42), and Adama, Ethiopia (34). This could be due to the mother's low level of education, a lack of nutrition knowledge, or the fact that they are not formally educated and cannot understand different promotions. As a result, her decision-making ability and contribution to the total family income will be limited. It could also have an impact on the type of food that is made and supplied.

Adolescents from households with more than five individuals were 2.4 times thinner than those from households with fewer than three members. Axum Town in North Ethiopia (36) and Riyadh, Saudi Arabia (48), have both reported similar occurrences. This could be due to the numerous household members sharing the available food and increased competition for food, which could impair both the quality and amount of food served at home, resulting in insufficient food consumption and thinness.

When it comes to dietary diversity, adolescents with insufficient nutritional diversity were 4.8 times thinner than those with substantial dietary diversity. This result was similar to those reported in Karnataka, India (35), and Axum, Ethiopia (36). This could be attributed to a lack of nutritional diversification and irregular meals.

Limitation

The current study is cross-sectional in design, which does not establish a causal relationship between the outcome variable and independent factors. In addition, we utilized a 24-hour recall to account for the number of food categories ingested which might be affected by recall and social desirability bias.

Conclusion and recommendation

Adolescent stunting and thinness were common. Thinness was connected to parental education, family size, and individual dietary diversity. Stunting was also linked to household income, family size, food insecurity, and dietary diversity. Therefore, to decrease adolescent undernutrition, the government of Addis Ababa city administration should prioritize minimizing food insecurity while boosting productivity to enhance adolescent nutritional diversity. Moreover, nutrition and contraceptive education should be strengthened by healthcare providers working at public schools and health extension workers.

Declaration

Ethical consideration

The researchers secured ethical approval from Kotebe University of Education, Menelik II Medical and Health Science College research and ethical review board with reference number ID KUE/38/12/3027. Official letters were obtained from the Addis Ababa health bureau, and an authorization letter was provided by the Lideta sub-city educational office. Following a thorough explanation of the study objectives to the adolescent parents or legal guardians, the data of the adolescent students was collected after having their informed written consent.

Consent for publication

Not applicable

Data Availability

The datasets used to support the findings of this study are attached with the manuscript.

Conflicts of interest

The author declares they have no competing conflicts of interest.

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Author contributions

AA: This author helped on substantial intellectual contributions to conception, design, and acquisition of data, analysis, and interpretation, EA: have contributed to conception, design, and data interpretation, TS: This author contributed for the study design, analysis and give approval of the final version to be published, and GKG: has been involved in analysis, interpretation of data and drafting the manuscript and revising it critically for important intellectual contents.

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Figure 2: Adolescent stunting and thinness in public schools of Lideta sub-city, Addis Ababa, Ethiopia 2021

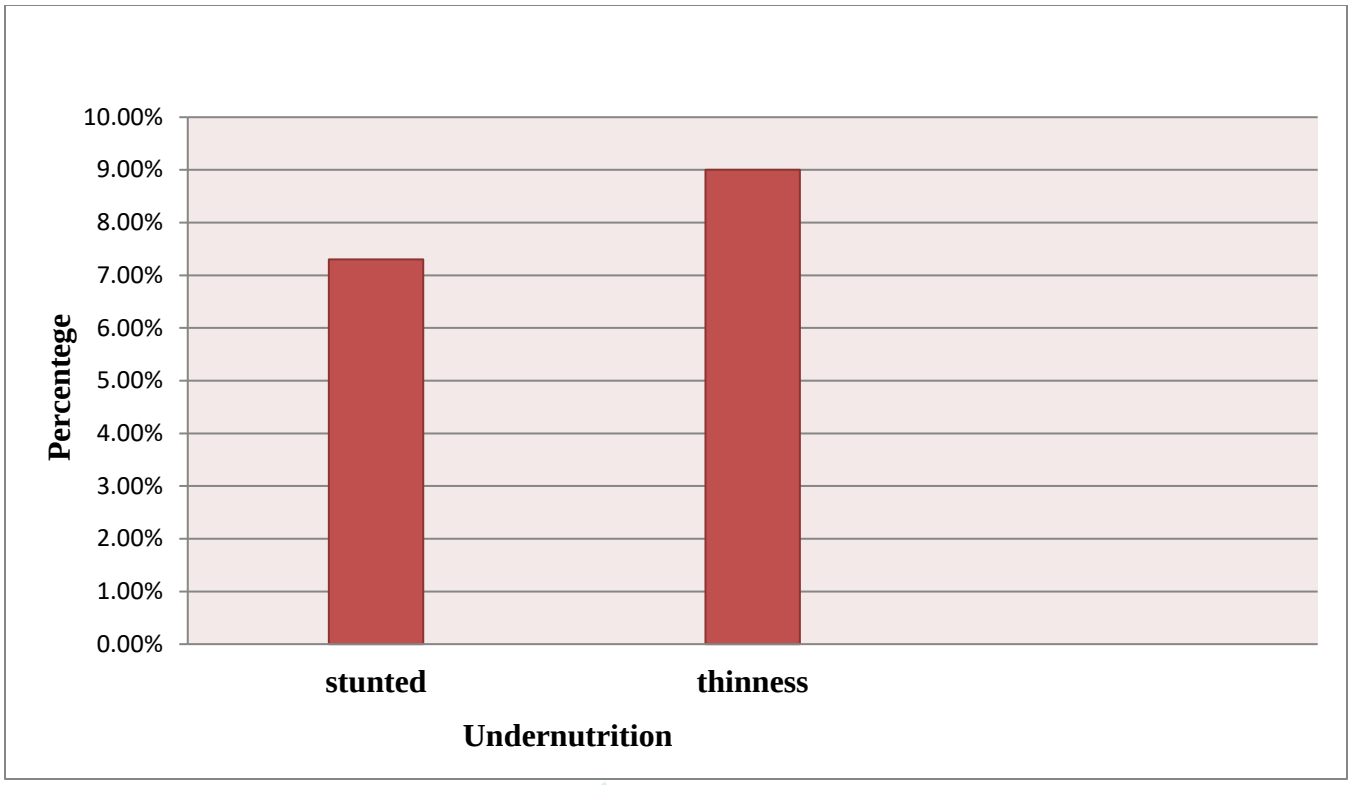

Figure 1: undernutrition status among adolescent students in public schools of Lideta sub city, Addis Ababa, Ethiopia in 2021

The STROCSS 2021 Guideline		
Item no.	**Item description**	**Page**
TITLE		
1	**Title** • The word cohort or cross-sectional or case-control is included* • Temporal design of study is stated (e.g. retrospective or prospective) • The focus of the research study is mentioned (e.g. population, setting, disease, exposure/intervention, outcome etc.) *STROCSS 2021 guidelines apply to cohort studies as well as other observational studies (e.g. cross-sectional, case-control etc.)	1
ABSTRACT		
2a	**Introduction** – briefly describe: • Background • Scientific rationale for this study • Aims and objectives	2
2b	**Methods** - briefly describe: • Type of study design (e.g. cohort, case-control, cross-sectional etc.) • Other key elements of study design (e.g. retro-/prospective, single/multi-centred etc.) • Patient populations and/or groups, including control group, if applicable • Exposure/interventions (e.g. type, operators, recipients, timeframes etc.) • Outcome measures – state primary and secondary outcome(s)	2
2c	**Results** - briefly describe: • Summary data with qualitative descriptions and statistical relevance, where appropriate	2
2d	**Conclusion** - briefly describe: • Key conclusions • Implications for clinical practice • Need for and direction of future research	2
INTRODUCTION		
3	**Introduction** – comprehensively describe: • Relevant background and scientific rationale for study with reference to key literature • Research question and hypotheses, where appropriate • Aims and objectives	2
METHODS		
4b	**Ethical approval** • Reason(s) why ethical approval was needed • Name of body giving ethical approval and approval number • Where ethical approval wasn't necessary, reason(s) are provided	20
4c	**Protocol** • Give details of protocol (*a priori* or otherwise) including how to access it (e.g. web address, protocol registration number etc.) • If published in a journal, cite and provide full reference	
4d	**Patient and public involvement in research** • Declare any patient and public involvement in research • State the stages of the research process where patients and the public were involved (e.g. patient recruitment, defining research outcomes, dissemination of results etc.) and describe the extent to which they were involved.	9

5a	**Study design** • State type of study design used (e.g. cohort, cross-sectional, case-control etc.) • Describe other key elements of study design (e.g. retro-/prospective, single/multi-centred etc.)	4
5b	**Setting and timeframe of research** – comprehensively describe: • Geographical location • Nature of institution (e.g. primary/secondary/tertiary care setting, district general hospital/teaching hospital, public/private, low-resource setting etc.) • Dates (e.g. recruitment, exposure, follow-up, data collection etc.)	3
5c	**Study groups** • Total number of participants • Number of groups • Detail exposure/intervention allocated to each group • Number of participants in each group	4
5d	**Subgroup analysis** – comprehensively describe: • Planned subgroup analyses • Methods used to examine subgroups and their interactions	8
6a	**Participants** – comprehensively describe: • Inclusion and exclusion criteria with clear definitions • Sources of recruitment (e.g. physician referral, study website, social media, posters etc.) • Length, frequency and methods of follow-up (e.g. mail, telephone etc.)	4
6b	**Recruitment** – comprehensively describe: • Methods of recruitment to each patient group (e.g. all at once, in batches, continuously till desired sample size is reached etc.) • Any monetary incentivisation of patients for recruitment and retention should be declared; clarify the nature of any incentives provided • Nature of informed consent (e.g. written, verbal etc.) • Period of recruitment	4
6c	**Sample size** – comprehensively describe: • Analysis to determine optimal sample size for study accounting for population/effect size • Power calculations, where appropriate • Margin of error calculation	4
METHODS - INTERVENTION AND CONSIDERATIONS		
7a	**Pre-intervention considerations** – comprehensively describe: • Preoperative patient optimisation (e.g. weight loss, smoking cessation, glycaemic control etc.) • Pre-intervention treatment (e.g. medication review, bowel preparation, correcting hypothermia/-volemia/-tension, mitigating bleeding risk, ICU care etc.)	5
7b	**Intervention** – comprehensively describe: • Type of intervention and reasoning (e.g. pharmacological, surgical, physiotherapy, psychological etc.) • Aim of intervention (preventative/therapeutic) • Concurrent treatments (e.g. antibiotics, analgesia, anti-emetics, VTE prophylaxis etc.) • Manufacturer and model details, where applicable	5
7c	**Intra-intervention considerations** – comprehensively describe: • Details pertaining to administration of intervention (e.g. anaesthetic, positioning, location, preparation, equipment needed, devices, sutures,	6

	operative techniques, operative time etc.) • Details of pharmacological therapies used, including formulation, dosages, routes, and durations • Figures and other media are used to illustrate	
7d	**Operator details** – comprehensively describe: • Requirement for additional training • Learning curve for technique • Relevant training, specialisation and operator's experience (e.g. average number of the relevant procedures performed annually)	7
7e	**Quality control** – comprehensively describe: • Measures taken to reduce inter-operator variability • Measures taken to ensure consistency in other aspects of intervention delivery • Measures taken to ensure quality in intervention delivery	7
7f	**Post-intervention considerations** – comprehensively describe: • Post-operative instructions (e.g. avoid heavy lifting) and care • Follow-up measures • Future surveillance requirements (e.g. blood tests, imaging etc.)	8
8	**Outcomes** – comprehensively describe: • Primary outcomes, including validation, where applicable • Secondary outcomes, where appropriate • Definition of outcomes • If any validated outcome measurement tools are used, give full reference • Follow-up period for outcome assessment, divided by group	5
9	**Statistics** – comprehensively describe: • Statistical tests and statistical package(s)/software used • Confounders and their control, if known • Analysis approach (e.g. intention to treat/per protocol) • Any sub-group analyses • Level of statistical significance	8
RESULTS		
10a	**Participants** – comprehensively describe: • Flow of participants (recruitment, non-participation, cross-over and withdrawal, with reasons). Use figure to illustrate. • Population demographics (e.g. age, gender, relevant socioeconomic features, prognostic features etc.) • Any significant numerical differences should be highlighted	9
10b	**Participant comparison** • Include table comparing baseline characteristics of cohort groups • Give differences, with statistical relevance • Describe any group matching, with methods	10
10c	**Intervention** – comprehensively describe: • Degree of novelty of intervention • Learning required for interventions • Any changes to interventions, with rationale and diagram, if appropriate	11
11a	**Outcomes** – comprehensively describe: • Clinician-assessed and patient-reported outcomes for each group • Relevant photographs and imaging are desirable • Any confounding factors and state which ones are adjusted	14
11b	**Tolerance** – comprehensively describe: • Assessment of tolerability of exposure/intervention • Cross-over with explanation	---

	• Loss to follow-up (fraction and percentage), with reasons	
11c	**Complications** – comprehensively describe: • Adverse events and classify according to Clavien-Dindo classification* • Timing of adverse events • Mitigation for adverse events (e.g. blood transfusion, wound care, revision surgery etc.) *Dindo D, Demartines N, Clavien P-A. Classification of Surgical Complications. A New Proposal with Evaluation in a Cohort of 6336 Patients and Results of a Survey. Ann Surg. 2004; 240(2): 205-213	4
12	**Key results** – comprehensively describe: • Key results with relevant raw data • Statistical analyses with significance • Include table showing research findings and statistical analyses with significance	16
DISCUSSION		
13	**Discussion** – comprehensively describe: • Conclusions and rationale • Reference to relevant literature • Implications for clinical practice • Comparison to current gold standard of care • Relevant hypothesis generation	17
14	**Strengths and limitations** – comprehensively describe: • Strengths of the study • Weaknesses and limitations of the study and potential impact on results and their interpretation • Assessment and management of bias • Deviations from protocol, with reasons	20
15	**Relevance and implications** – comprehensively describe: • Relevance of findings and potential implications for clinical practice • Need for and direction of future research, with optimal study designs mentioned	20
CONCLUSION		
16	**Conclusions** • Summarise key conclusions • Outline key directions for future research	20
DECLARATIONS		
17a	**Conflicts of interest** • Conflicts of interest, if any, are described	21
17b	**Funding** • Sources of funding (e.g. grant details), if any, are clearly stated • Role of funder	21
17c	**Contributorship** • Acknowledge patient and public involvement in research; report the extent of involvement of each contributor	21

The full revised STROCSS 2021 checklist

BMJ Open

Prevalence and correlates of stunting and thinness among adolescent students in Lideta sub-city, Addis Ababa, Ethiopia a cross-sectional study

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Prevalence and correlates of stunting and thinness among adolescent students in Lideta sub-city, Addis Ababa, Ethiopia a cross-sectional study

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Abstract

Objectives: To determine the prevalence of stunting and thinness and associated factors among adolescents attending public schools in Lideta sub-city, Addis Ababa, Ethiopia, 2021.

Design: Cross-sectional

Setting: Public schools of Lideta sub-city, Addis Ababa, Ethiopia

Eligibility: Adolescents from grade 5–12 in the public schools and students whose parents gave consent for participation.

Data analysis: Bivariate and multivariable logistic regression analysis were used to examine the association between the independent variables and stunting and thinness. Using a 95% confidence interval (CI) and adjusted odds ratio (AOR), factors with a p-value of less than 0.05 were determined to have a significant association.

Outcome measures: The prevalence of stunting and thinness, as well as the factors associated with stunting and thinness, were secondary outcomes.

Results: The overall, prevalence of stunting and thinness was 7.2%: 95% CI (5.3–9.3%) and 9%: 95% CI (6.8–11.4%) respectively. Stunting was associated with larger family size AOR = 3.76: 95% CI (1.58-8.94), low dietary diversity AOR = 2.87: 95% CI (1.44-5.74), food insecurity AOR = 2.81: 95% CI (1.38-5.71), and lower wealth index AOR = 3.34: 95% CI (1.51-7.41). While thinness was associated with maternal education who were unable to read and write AOR = 2.5: 95% CI (1.97- 8.01), inadequate dietary diversity AOR = 4.81: 95% CI (2.55-9.07), and larger family size AOR = 2.46: 95.0% CI (1.14-5.29).

Conclusion: Adolescent stunting and thinness were common in Addis Ababa public schools. Family size, dietary diversity, and food security were the main factors associated with both thinness and stunting. Therefore, to decrease adolescent stunting and thinness, the government of Addis Ababa city administration should prioritize minimizing food insecurity while boosting productivity to enhance adolescent nutritional diversity. Moreover, nutritional education should be strengthened by healthcare providers working at public schools and health extension workers.

Keywords: stunting, thinness, undernutrition, adolescence, public schools, Ethiopia

Strength and limitation of the study

- The study had a larger sample size (678) and a maximum response rate (100%).

- The study used a cross-sectional study design, which does not establish a causal relationship between the outcome variable and independent factors.
- The finding of this study might be affected by recall and social desirability bias.

Introduction

According to the World Health Organization (WHO), adolescence is defined as the period from 10 to 19 years during which an individual undergoes major physical growth, mental development, and psychological changes (1, 2). There are nearly 1.3 billion adolescents worldwide, accounting for 16% of the global population (3). Particularly in Ethiopia, children and adolescents make up around 48% of the overall population (4). Adolescents gain up to 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeletal mass as a result of increased dietary needs (5).

Suboptimal nutrition during this period leads to undernutrition with consequences for their health and sexual development (6). In low- and middle-income countries, malnutrition, particularly undernutrition, is very common among adolescents (7, 8). In a study that examined the global trend in 24.1 million children's nutritional status between the ages of 5 and 17 years, it was shown that the prevalence of underweight had decreased in all but South Asia, Central Africa, East Africa, and West Africa (9). Since both under- and overnutrition coexist in the majority of sub-Saharan African countries, including Ethiopia, they are facing a phenomenon called the "double burden of malnutrition" (10). Moreover, the prevalence of stunting and thinness in developing nations among adolescents ranges from 32 to 48% (11, 12), particularly in Ethiopia, where it was reported to be 7.2 to 26.5% (13).

The triple burden of malnutrition includes undernutrition (underweight, stunted or wasted), micronutrient deficiency, and overweight and obesity (weight that is greater than what is considered healthy for one's height) (14). Undernutrition in adolescence manifests as stunting and thinness, which have the potential to reduce learning capacity, delay sexual maturation, cause inattentiveness, impede academic performance, weaken physical and economic progress, restrict the body's capacity to absorb nutrients properly, and prolong poverty (15-17).

Undernutrition in adolescents is best measured by two major indicators: the low BMI (body mass index) for age, which is less than two standard deviations (SD), and stunting, which is the low

height for age, which is less than two SD (18). Adolescents' nutritional status is affected by a variety of circumstances. The key determinants are socioeconomic status, age, sex, household income, marital status, family size, maternal education, food insecurity, dietary diversity, patterns, and habits (19, 20).

Undernutrition during the adolescent period diminishes the working capacity of an individual during adulthood (21, 22). Ultimately, it silently destroys the future socio-economic development of a nation and even causes the cruel cycle of intergenerational undernutrition by causing parents to share the consequences with their children, including low birth weight, short stature, and low resistance to infection (23-25). This problem would be devastating in Ethiopia, where about 27.7% of adolescent girls become pregnant at the age of nineteen (26).

Ethiopia has been working to reduce the high burden of undernutrition through the implementation of national programs like the National Nutrition Program (NNP), including school feeding, for the past three years in Addis Ababa. As far as our knowledge is concerned, this is the first study since the start of the public-school feeding program. Therefore, the study aims to assess stunting, thinness, and associated factors among adolescents in Lideta, a sub-city of Addis Ababa, Ethiopia, in 2021.

Methods

Study area and period: The study was conducted in the Lideta sub-city of Addis Ababa, Ethiopia. The Lideta sub-city is one of the eleven sub-cities of Addis Ababa city administration, located in the central part of the town. Information obtained from the Lideta sub-city educational office reported that there were eighteen primary schools and three secondary schools. In the academic year 2020-2021, around 10,033 adolescents were registered. Of these, 3,431 were in secondary schools, and the remaining were in primary schools.

In Addis Ababa, a large-scale SFP (School Feeding Program) was launched in February 2019 with the goal of feeding kids in public elementary schools to reduce hunger in the classroom. The education bureau of Addis Ababa municipal administration owns and funds the Addis Ababa SFP, which provides two meals for students each day (breakfast and lunch each school day). The food menu states that throughout the course of a week, a total of eleven different food types and items

are served for both breakfast and lunch. The school lunch consists of rice, bread, marmalade, shiro-based, fir fir, potato-based sauce, white bread (difo), injera, refined bread, tea, and boiled eggs. All of the public elementary schools in Addis Ababa provide identical school lunches (27). The study was conducted from May 20th to June 5th, 2021 using an institution-based cross-sectional study design.

Source population: All adolescent students in public schools enrolled in Lideta sub-city, Addis Ababa, Ethiopia.

Study population: All school adolescents enrolled within randomly selected primary and secondary schools of Lideta Sub-city, Addis Ababa, Ethiopia.

Eligibility criteria

Inclusion criteria

Adolescents from grades 5–12 in the selected public schools and students whose parents gave consent participated in the study.

Exclusion criteria

Those public-school adolescents who were seriously ill and absent for any reason during the data collection period were excluded from the study.

Sample size determination and sampling procedure

The sample size was calculated using the single population proportion formula.

$$n = \frac{(Z\frac{\alpha}{2})^2 P(1-P)}{d^2}$$

The magnitude of stunting and thinness from the previous studies was considered 20.7 and 22% (17, 28), with a precision of 4%, a 95% confidence interval, a design effect of 1.5, and adding a 10% non-response rate, the maximum sample size was 678.

For this study, seven primary and two secondary schools were selected using simple random sampling techniques among the eighteen primary and three secondary schools that were available in the Lideta sub-city. Each school and class (grades 5–12) found in each selected school received a proportional allocation of the sample size. Each school's administrators provided a sampling

frame (a list of adolescents aged 10–19 years). Finally, a simple random sample strategy was utilized to pick study participants by using the student list as a sampling frame.

Study variables

The presence or absence of thinness as defined by having a BMI for age (BAZ) value less than two standard deviations from the WHO child growth standard and stunting as measured by a height for age (HAZ) value less than two standard deviations from the WHO child growth standard were considered as an outcome variable of this study. Besides, sociodemographic characteristics such as age (10-13, 14-16, 17-19), wealth index (poor, middle, wealthy), family size (3, 4-5, >5), parents' education (unable to read and write, able to read and write, primary education, secondary education, college and above), dietary diversity (good, poor), and environmental factors such as toilet (absence, presence) were all used as independent variables.

Data collection methods and procedures

Four diploma nurses and two BSC health officers were hired as data collectors and supervisors, respectively. Data was collected through a face-to-face interview using a structured and pre-tested questionnaire. The data collection began with the permission and consent of student parents at their residence. The parents were quizzed on sociodemographic factors, food security, wealth index, environmental sanitation, and hygiene in their home. Questionnaire-administered interviews with all of the parents (mothers or fathers) of students were conducted at their homes in the afternoon as soon as the children arrived home. The remaining individual dietary information was obtained from the adolescent.

The questionnaire for this study was adopted from the EDHS (Ethiopian Demographic Health Survey) (19) and reviewed in the literature of similar studies (7, 8, 18). The tool contains sociodemographic, nutritional, environmental, and dietary factors.

Height measurement

Setting up the measurement site

The height was measured with a stadiometer applied vertically to a hard, flat wall surface with the base at floor level. The vertical location of the rule was checked with a carpenter's level. In the absence of such a floor, a hard wooden platform was placed beneath the height base.

Setting up the measurement site

It was measured by a weighting scale (model 8811021659, made in Germany). The weighing balance was calibrated in kilograms, and students were weighed to the nearest 0.1 kg while dressed in light clothing and without shoes.

Measuring the dietary diversity score (DDS)

The DDS was used to assess nutritional adequacy, which was defined as the number of food categories ingested in a certain period of time, often 24 hours. Each respondent was questioned about the food they had eaten the previous day, both at home and away from it. Among those who consumed at least 4 different food groups the day before, obtained as minimal dietary diversity (MDD) from 8 different food categories (24-hour recall). The DDS of eight food categories (grains (white roots, tubers, and plantains), pulses (beans, peas, and lentils), nuts and seeds, dairy and eggs, dark green leafy vegetables, vitamin-A-rich fruits and vegetables, vegetables, and fruits) was used, and it was calculated by taking into account the type and number of food groups consumed by the households (23). Poor dietary diversity was defined as the dietary diversity score below the median value (less than 4 food groups), and good dietary diversity was categorized as adolescents who had a dietary diversity score at or above the median value (greater than or equal to 4 food groups) (28).

Measuring food insecurity in households

The household food insecurity access scale (HFIAS) developed by FANTA was used to determine the level of food insecurity in the household. The scale explores the occurrence and frequency of occurrence of nine food insecurity-related events in the past 30 days of the survey. The household was classified as either food secure or food insecure by the HFIAS (29).

The wealth index procedure

Questions from the Ethiopian demographic and health survey, 2016, were used to determine the wealth level of the households (19). Fourteen major variables (mobile phone, radio, chairs, tables, television, watch, jewelry, car, motorcycle, house, non-mobile telephone, refrigerator, bed with cotton/sponge/spring mattress, and computer) were analyzed. The values of each wealth variable were recoded as 0 and 1 before undertaking principal component analysis. Scores are assigned to households based on the number and types of consumer goods they own, including each durable good, from a television to a bicycle or car, as well as dwelling qualities like bathroom amenities and flooring materials. With the help of principal component analysis (PCA), wealth index scores

were created. By giving each household a score, rating each household according to that score, and then splitting the distribution into three equal groups, each of which includes 33% of the population, the wealth quintiles were created. Following that, PCA was used to rank the findings from lowest to highest into three groups: poor, medium, and wealthy, which were coded as 1, 2, and 3, respectively.

Operational Definition:

Thinness was taken as a BMI for age (BAZ) value of less than two standard deviations from the WHO Child Growth Standard (30).

Stunting was defined as a height for age (HAZ) value of less than two standard deviations from the WHO Child Growth Standard (30).

Poor dietary diversity: Adolescents with a dietary diversity score below the median value of less than 4 food groups (24).

Good dietary diversity: Adolescents were measured using a qualitative recall of all foods consumed by each adolescent during the previous 24 hours through a standardized and validated tool containing 8 food groups taken from verbal reports of the participants, and we considered an adolescent to have adequate dietary diversity if they reported consuming four or more food groups (11).

A food-secure household: A household with a score of 0–1 on the Household Food Insecurity Access Scale (HFIAS) is classified as food-secure (30).

Food insecure households: Based on an HFIAS score (0–27) of 2 and above, they were considered food insecure (31).

Quality assurance

In order to maintain the quality of the data, training was provided to data collectors and supervisors for one day by the principal investigators. The questionnaire was prepared first in English and then translated to the local language, Amharic, and back to English to check its consistency. A pretest was conducted on 5% of the subjects at Addis Ketema sub-city public schools, and the scales were carefully handled and periodically calibrated by placing standard calibration weights of 2 kg iron bars on the scales. On-site supervision was performed, and each copy of the questionnaire was checked for completeness and accuracy before data entry.

Data processing and analysis

For cleaning, recoding, and categorizing variables, the collected data was entered into EPI Info 3.1 computer programs and exported to the Statistical Package for Social Sciences (SPSS) version 21 for analysis. In addition, WHO Anthro-Plus software was used to enter and analyze anthropometric data. PCA was used to examine the household wealth index. The Keiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to verify the statistical assumptions of factor analysis. As a result, a KMO of 0.5 or above, as well as a significant Bartlett's test of sphericity (p-value of 0.05), were deemed sufficient to satisfy the assumption.

Moreover, communality values and eigenvalues of 0.5 and greater than 1 were included in the factor analysis. The variables with less than 0.5 of the communality value were removed from the analysis, and the analysis was done repeatedly until all variables met the inclusion criteria for factor analysis. Next, all eligible factor scores were computed using the regression-based method to generate one variable, wealth status. Then, afterward, the loading factors were sorted in ascending order. Following this, the final scores were ranked into three quartiles, namely first, second, and third. Finally, ranks were interpreted as poor, medium, and wealthy, respectively. A descriptive summary (frequency distribution, proportion, mean, and standard deviation) was used to summarize the variable.

Binary logistic regression analysis was used to ascertain the association between explanatory and outcome variables. A variable whose p-value was less than 0.2 in the bivariate analysis was entered into the multivariable logistic regression analysis to determine factors associated with stunting and thinness. In the multivariable analysis, a p-value of less than 0.05 and an odds ratio with 95% CI were used to declare the presence and strength of association.

Patient and public involvement

Throughout the data collection period parents or the legal guardians of the study participants and public-school teachers were involved with a free support and advice for the researchers related with ethical issues and advice on how to share our findings to a wide audience, in a way the public can understand.

Results

Socio-demographic characteristics of adolescents and their families

A total of 678 adolescent students were included in the study with a 100% respondent rate. Males made up nearly half (364, or 53.7%) of the study participants. The average age of the respondents was 15 (SD 2.4) years, with a range of 11 to 19 years. Almost one third (211, or 31.6%) of the study participants were early adolescents. The majority of participants (446, or 65.8%) were from primary schools. In terms of their parents' occupation status, nearly a quarter (173 or 25.5%) of their fathers and 158 (23.3%) of their moms were government employed and housewives, respectively (Table 1).

Table 1: Sociodemographic characteristics of the study participants among adolescent students in a public school in Lideta sub-city, Addis Ababa, Ethiopia (n = 678)

Variables	Category	Frequency	Percent (%)
Sex	Male	364	53.7
	Female	314	46.3
Adolescent age	10-13	219	32.3
	14-16	296	43.7
	17-19	163	24
Adolescent grade	Primary school	446	65.8
	Secondary school	231	34.1
Fathers' educational status	Unable to read and write	77	11.4
	Able to read and write	233	34.4
	Primary education	147	21.7
	Secondary education	106	15.6
	College and above	84	12.4

Mother's education	Unable to read and write	85	12.5
	Able to read and write	147	21.7
	Primary education	167	24.6
	Secondary education	100	14.8
	College and above	80	11.8
Family size	<3	204	30.1
	4-5	217	32
	>5	257	37.9
School feeding	Yes	446	65.8
	No	232	34.2

*Primary school consists of grades five to eight, and *secondary school includes grades nine to twelve.

The dietary diversity status of adolescents

The mean (SD) dietary diversity score in the study group was 4.2 (2). The proportion of adolescents who consumed good dietary diversity was 389 (57.4%) and the proportion of adolescents who consumed poor dietary diversity was 289 (42.6%). The greater proportion of 594 (90.4%) of the study participants consumed food containing cereals, while only 187 (28%) of respondents reported consuming animal products (table 2).

Table 2: Dietary diversity among adolescents in public schools of Lideta sub-city, Addis Ababa, Ethiopia 2021

Variable	**Response**	**Frequency**	**Percentage**
Grains, Root or Tuber	Yes	597	88.1

	No	81	11.9
Vitamin A rich fruit and vegetable.	Yes	401	59.1
	No	277	40.9
Fruits and Vegetables	Yes	350	48.4
	No	328	51.6
Meat, poultry, offal and Fish	Yes	193	28.5
	No	485	71.5
Eggs (eggs)	Yes	199	70.6
	No	479	29.4
Pulses, Legumes, nuts and seeds	Yes	257	37.9
	No	421	62.1
Milk& milk products	Yes	296	43.7
	No	382	56.3
Food cooked Oils and Fats	Yes	532	78.5
	No	146	21.5

*Vitamin A-rich fruits and vegetables include red, yellow, and green leafy vegetables like carrots, cabbage, sweet potatoes, mango, and papaya.

Wealth index and food security status of households

Regarding household food security measurement, the study participants were asked to report the frequency of worrying about what to eat and the range of remaining hunger day and night in the previous four weeks before the survey. Based on the nine HFIAS questions' responses, their frequencies of occurrence over the past 30 days were assessed. As a result, more than half (381, or 56.2%) of the households were food secure, and 297, or 43.8 percent, were food insecure.

Moreover, according to wealth classification, 231 (34.1%) of households had poor assets, while 207 (30.5%) and 240 (35.4%) were classified as medium-asset and rich-asset households, respectively.

Adolescent eating habits and frequency

The adolescents' eating habits were analyzed based on adolescent and their parents' reports on their meal frequency; subsequently, 348 (52.2%) of the adolescents consumed meals three times per day, while 36.1% of the respondents did not eat meat once a week. while the vast majority of adolescents (92.2%) eat injera at home. Almost half of the students (45%) do not consume fruit on a weekly basis (table 3).

Table 3: Eating habits and frequency among adolescents in public schools of Lideta sub-city, Addis Ababa, 202

Variable	**Category**	**Frequency**	**Percentage**
Meal frequency	Once a day	12	1.8
	Twice a day	190	28
	Three times a day	323	47.6
	More than four times	152	22.6
Frequency of meat eating in week	Never	134	19.8
	Once a week	166	24.5
	Twice a week	152	22.4
	Three times a week	117	17.5
	More than three times a week	109	16
Soft drinks in one week	Never	160	23.3
	Once a week	136	20.1
	Twice a week	180	26.5
	Three times a week	78	11.5
	More than three times a week	104	15.3

Drink citrus fruit, in week	Never	138	20.4
	Once a week	172	25.4
	Twice a week	256	37.8
	More than twice per week	112	16.5
Eating egg in week	Never	263	38.8
	Once a week	95	14
	More than twice a week	175	28.5
	Every day	143	21.4
Drink Milk and milk products in week	Never	235	34.7
	Once a week	185	27.3
	More than twice a week	125	18.4
	Once a day	133	19.6
Staple food in the family	Injera	495	72.7
	Bread	154	22.7
	Other	31	4.5

Prevalence of stunting and thinness among adolescents in public schools

The overall prevalence of stunting and thinness among adolescents was 49 (7.2%) (95%CI (5.3-9.3%) and 61 (9%) (95%CI (6.8-11.4%) respectively (figure 1). Thinness was more common among adolescents aged 17–19 years (11%), compared with age groups 14–16 years (8.8%) and 10–13 years (7.8%). Similarly, stunting was more prevalent among 17-19 years of adolescents 9.8% whereas it was 8.2 and 5.1% among 10-13 and 14-16 years respectively. Besides, thinness was more than two times as common and stunting was nearly four times as prevalent among school-age adolescents from food-insecure households compared with their counterparts, and the proportions of thinness and stunting among adolescents who had poor dietary diversity were 15.9 and 12.5%, respectively. Based on sex category both thinness and stunting were higher among males 11% and 8.5% respectively compared with females (table 4).

Table 4: Proportion of thinness and stunting in relation to different variables of adolescents in public school students of Lideta sub city, Addis Ababa, 2021.

Variables	Thinness		Stunting	
	Yes	No	Yes	No
Sex				
Male	40 (11%)	324 (89%)	31 (8.5%)	333 (91.5%)
Female	21 (6.7%)	293 (93.3%)	18 (5.7%)	296 (94.3%)
Age group				
10-13	17 (7.8%)	202 (92.2%)	18 (8.2%)	201 (91.8%)
14-16	26 (8.8%)	270 (91.2%)	15 (5.1%)	281 (94.9%)
17-19	18 (11.0%)	145 (89.0%)	16 (9.8%)	147 (90.2%)
Food security				
Secured	22 (5.8%)	359 (94.2%)	12 (3.1%)	369 (96.9%)
Insecured	39 (13.1%)	258 (86.9%)	37 (12.5%)	260 (87.5%)
Wealth index				
Poor	26 (11.3%)	205 (88.7%)	31 (13.4%)	200 (86.6%)
Middle	18 (8.7%)	189 (91.3%)	9 (4.3%)	198 (95.7%)
Wealthy	17 (7.1%)	223 (92.9%)	9 (3.8%)	231 (96.2%)
Dietary diversity				
Good	15 (3.9%)	374 (96.1%)	13 (3.3%)	376 (96.7%)
Poor	46 (15.9%)	243 (84.1%)	36 (12.5%)	253 (87.5%)

Factors associated with stunting among adolescents

The bivariate regression analysis indicated that sex, family size, the mother's occupation, dietary diversity, household food insecurity, and wealth index were associated with stunting. While, in multivariable analysis, family size, individual dietary diversity, household food insecurity, and wealth index were statistically and independently associated with stunting.

Adolescents with a family size of more than five had nearly four-times higher risk of stunting than those with a family size of less than three [AOR = 3.764; 95% CI = (1.583-8.94)]. Similarly, participants who were food insecure at the household level were three times more likely to be stunted [AOR = 2.804; 95% CI = (1.378–5.706)]. Furthermore, the chances of stunting were three times higher among participants with poor dietary diversity compared with their counterparts [AOR = 2.870; 95% CI (1.435-5.741)]. The odds of stunting were also higher among adolescent students from poor families [AOR = 3.343; 95% CI (1.510–7.403)] (table 5).

Table 5: Bivariate and multivariable logistic regression analysis for stunting among adolescent students in Lideta sub-city, Addis Ababa, 2021

Variables	Stunted		COR (95% CI)	AOR (95% CI)	P-value
	Yes	No			
Sex					
Male	31 (4.6%)	333 (49.1%)	1.51 (.282-2755)	1.316 (.307-5.631)	.556
Female	18 (2.7%)	296 (43.4%)	1	1	
Family size					
<3	7 (1%)	197 (29.1%)	1	1	
4-5	9 (1.3%)	208 (30.7%)	1.862 (.844- 4.106)	1.113 (.396-3.125)	.839
>5	33 (4.9%)	224 (33%)	2.759 ((1.32-5.75)	**3.77 (1.583-8.948)**	.003**
Mother occupation					
House wife	19 (3%)	140 (21.9%)	3.046 (1.33-6.929)	1.358 (.455-4.052)	.583

Daily laborer	6 (0.9%)	73 (11.4%)	1.845 (.635-5.363)	.979 (.252-4.128)	.977
Governmental	10 (1.6%)	129 (20.2%)	1.740 (.688-4.398)	2.002 (.583-6.876)	.270
Non-government	4 (0.6%)	46 (7.2%)	1.952 (.576-6.614)	1.257 (.190-8.312)	.813
Self-employ	9 (1.4%)	202 (31.7%)	1	1	
House hold food security status					
Food secure	12 (1.8%)	369 (54.4%)	1	1	
Food insecure	37 (5.5%)	260 (38.3%)	4.376 (2.239-8.553)	**2.804 (1.378-5.706)**	.004**
Individual dietary diversity score					
Good dietary	13 (1.9%)	376 (55.5%)	1	1	
Poor dietary	36 (5.3%)	253 (37.3%)	4.116 (2.14-7.914)	**2.870 (1.435-5.741)**	. 005**
Wealth Index					
Poor	31 (4.5%)	200 (29%)	3.978 (1.850-8.557)	**3.343 (1.510-7.403)**	.001**
Middle	9 (1.3%)	198 (29.2%)	1.178 (.454-2.998)	1.190 (.450-3.142)	.726
Wealthy	9 (1.3%)	231 (34.1%)	1	1	

Reference category: significant at a p–value of <0.05*, significant at a p–value of <0.01**

Factors associated with thinness among adolescent students

Bivariate study revealed that sex, family size, mother's education, father's career, individual dietary diversity, household food security, and wealth index were all related to thinness. Multivariable analysis, however, showed that family size, mother education, and individual dietary diversity were statistically and independently related with thinness after controlling for confounding variables. Accordingly, adolescents from a family size of more than five were nearly 2.4 times more likely than those with a family size of less than three to acquire thinness [AOR=2.458, 95 percent CI: (1.140-5.296)].

Similarly, the odds of being thin were three times higher among participants whose mothers were not able to read and write compared with participants whose mothers had a college diploma and above [AOR = 2.59; 95% CI (1.969–8.003)]. Individuals with insufficient dietary diversity had a

nearly five-fold higher risk of being thin than their peers [(AOR=4.812:95 percent CI (2.552–9.072)] (table 6).

Table 6: Bivariate and multivariable analysis of thinness among adolescents in public school students of Lideta sub city, Addis Ababa, 2021.

Variables	Thinness		COR (95% CI)	AOR (95% CI)	p-value
	Yes	No			
Sex					
Male	40 (5.9%)	324 (47.8%)	1.72 (.993-2.989)	1.29 (.675-2.77)	.439
Female	21 (3.1%)	293 (43.2%)	1	1	
Family size					
<3	10 (1.5 %)	194 (28.6%)	1	1	
4-5	19 (2.8%)	198 (29.2%)	1.86 (.844-4.106)	1.607 (.707-3.64)	.257
>5	32 (4.7%)	225 (33.2%)	2.76 (1.32-5.75)	**2.45 (1.140-5.29)**	.022*
Mother Education					
Unable to read and write	12 (1.9%)	73 (11.6%)	3.18 (1.05-9.54)	**2.593 (1.969-8.03)**	0.05*
Able to read and write	9 (1.4%)	138 (21.8%)	1.36 (.473-3.923)	2.401 (.758-7.612)	.137
Primary education	15 (2.4%)	152 (24.1%)	1.51 (.535-4.212)	2.377 (.765-7.380)	.134
Secondary education	16 (2.5%)	117 (18.5%)	1.13 (.356-3.593)	2.387 (.342-7.706)	.146
College and above	5 (0.8%)	95 (15%)	1	1	
HHFS					
Food secure	22 (3.2%)	359 (52.9%)	1	1	
Food insecure	39 (5.8%)	258 (38.1%)	2.47 (1.42-4.261)	1.43 (.767-2.66)	.260
Individual dietary diversity					

Good dietary	15 (2.2%)	374 (55.2%)	1	1	
Poor dietary	46 (6.8%)	243 (35.8%)	4.72 (2.578-8.64)	**4.812 (2.55-9.07)**	. 001**
Wealth Index					
Poor	26 (3.8%)	205 (30.2%)	1.66 (.877-3.155)	1.39 (.668-2.925)	.374
Middle	18 (2.7%)	189 (27.9%)	1.25 (.626-2.492)	1.18 (.523-2.660)	.691
Wealthy	17 (2.5%)	223 (32.9%)	1	1	

Reference category: significant at p–value of <0.05*, significant at p–value of <0.01**

Discussion

The current study findings revealed that the prevalence of stunting and thinness was higher in male and older adolescents than in younger ones. The results were consistent with those of another study done in southern and central Ethiopia (32, 33). The possible explanation for the reason behind this might be due to the fact that those young adolescents participate in the school lunch program.

Overall, 7.2% of adolescents in public schools in Lideta, a sub-city of Addis Ababa, were stunted. When compared to a study report from Brazil (6%) (34) and Kenya (6.5%) (35), this result was higher. Differences in socioeconomical, cultural, and seasonal factors could explain the difference. However, this result was lower than those of research conducted in Damot Sore District, Southern Ethiopia (29.6%) (32) and in Adama City, Central Ethiopia (21.3%) (33). This disparity could be explained by a difference in income between the two research areas and study periods. Adolescents in Addis Ababa were more likely to have access to food, nutrition information, and educated households than those in Ambo and Adama City. Moreover, there is a school feeding program in Addis Ababa since 2019.

School adolescents who lived in households with five members or more were nearly four times more likely to be stunted than school adolescents who lived in households with three members. A study conducted in Dale, southern Ethiopia; Axum Town, northern Ethiopia; and Indonesia backed up the findings (35-37). This could be owing to the large number of family members sharing the limited food, resulting in insufficient food consumption and stunting. Furthermore, when family

size increased, per capita human inputs declined, which could be explained by a larger dependency ratio, resulting in poorer nutritious consumption among adolescent students.

Adolescents with poor dietary diversity were three times more likely to be stunted than their counterparts. This finding was consistent with a report from Dangila, western Ethiopia; Rabat, Morocco; and India (22, 38, 39). This could be explained by the fact that, in a phase of rapid growth and development, poor dietary diversity and irregular food intake are less likely to meet adolescents' nutritional requirements. As a result, failure to provide adequate food for daily body demand would result in stunting.

Household food insecurity was found to be significantly linked to stunting, with adolescents from food-insecure families were roughly three times more likely to have stunting than those from food-secure families. This finding was supported by data from Jimma, Southwest Ethiopia, the Somali Region, eastern Ethiopia, and a meta-analysis from developing regions (21, 40, 41). The possible explanation for this could be high market and food inflation, which may have negatively impacted the food security situation of urban households, in addition to seasonal variations within and across countries. As a result, adolescents may have reduced food intake, consumed poor-quality diets, or disrupted eating patterns, which can ultimately lead to stunting.

Adolescents from poor families were three times more stunted than those from wealthy families. This conclusion was backed up by research conducted in the Gurage zone, Ethiopia (42), Axum, northern Ethiopia (36), and Bihar, India (25). This could imply that the nutritional status of teenagers is solely determined by the socioeconomic position of the households in which they live. This further results in insufficient dietary quality and quantity due to the inability to purchase a variety of foods and eating preferences. Furthermore, adolescents from low-income households may have less access to and utilization of health care than those from wealthy families.

Thinness was found to be prevalent in 9% of the study populations. This finding was consistent with a study conducted in Debark, Northern Ethiopia, 10.3% (43) and yawned, Cameroon reported 9.5% (44). However, it was lower than studies in Mekelle City, northern Ethiopia, 26.1% (14), Western Kenya, 15.6% (45), and India, 20% (46). This gap could be attributable to the implementation of nutrition intervention programs in Addis Ababa public schools by state and nongovernmental organizations. Furthermore, cultural differences and socioeconomic disparities may play a role.

The odds of being skinny were 2.5 times greater among participants whose mothers couldn't read or write compared to participants whose mothers had a college diploma or higher educational standing. This result was similar to those found in Adwa, Ethiopia (47), Assam, India (42), and Adama, Ethiopia (34). This could be due to the mother's low level of education, a lack of nutrition knowledge, or the fact that they are not formally educated and cannot understand different promotions. As a result, her decision-making ability and contribution to the total family income will be limited. It could also have an impact on the type of food that is made and supplied.

Adolescents from households with more than five individuals were 2.4 times thinner than those from households with fewer than three members. Axum Town in North Ethiopia (36) and Riyadh, Saudi Arabia (48), have both reported similar occurrences. This could be due to the numerous household members sharing the available food and increased competition for food, which could impair both the quality and amount of food served at home, resulting in insufficient food consumption and thinness.

When it comes to dietary diversity, adolescents with insufficient nutritional diversity were 4.8 times thinner than those with substantial dietary diversity. This result was similar to those reported in Karnataka, India (35), and Axum, Ethiopia (36). This could be attributed to a lack of nutritional diversification and irregular meals.

Limitation

The current study is cross-sectional in design, which does not establish a causal relationship between the outcome variable and independent factors. In addition, we utilized a 24-hour recall to account for the number of food categories ingested which might be affected by recall and social desirability bias.

Conclusion and recommendation

Adolescent stunting and thinness were common. Thinness was connected to parental education, family size, and individual dietary diversity. Stunting was also linked to household income, family size, food insecurity, and dietary diversity. Therefore, to decrease adolescent undernutrition, the government of Addis Ababa city administration should prioritize minimizing food insecurity while boosting productivity to enhance adolescent nutritional diversity. Moreover, nutrition and contraceptive education should be strengthened by healthcare providers working at public schools and health extension workers.

Declaration

Ethical consideration

The researchers secured ethical approval from Kotebe University of Education, Menelik II Medical and Health Science College research and ethical review board with reference number ID KUE/38/12/3027. Official letters were obtained from the Addis Ababa health bureau, and an authorization letter was provided by the Lideta sub-city educational office. Following a thorough explanation of the study objectives to the adolescent parents or legal guardians, the data of the adolescent students was collected after having their informed written consent.

Consent for publication

Not applicable

Data Availability

The datasets used to support the findings of this study are attached with the manuscript.

Conflicts of interest

The author declares they have no competing conflicts of interest.

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Author contributions

AA: This author helped on substantial intellectual contributions to conception, design, and acquisition of data, analysis, and interpretation, EA: have contributed to conception, design, and data interpretation, TS: This author contributed for the study design, analysis and give approval of the final version to be published, and GKG: has been involved in analysis, interpretation of data

and drafting the manuscript and revising it critically for important intellectual contents.

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Figure 2: Adolescent stunting and thinness in public schools of Lideta sub-city, Addis Ababa, Ethiopia 2021

The STROCSS 2021 Guideline		
Item no.	**Item description**	**Page**
TITLE		
1	**Title** • The word cohort or cross-sectional or case-control is included* • Temporal design of study is stated (e.g. retrospective or prospective) • The focus of the research study is mentioned (e.g. population, setting, disease, exposure/intervention, outcome etc.) *STROCSS 2021 guidelines apply to cohort studies as well as other observational studies (e.g. cross-sectional, case-control etc.)	1
ABSTRACT		
2a	**Introduction** – briefly describe: • Background • Scientific rationale for this study • Aims and objectives	2
2b	**Methods** - briefly describe: • Type of study design (e.g. cohort, case-control, cross-sectional etc.) • Other key elements of study design (e.g. retro-/prospective, single/multi-centred etc.) • Patient populations and/or groups, including control group, if applicable • Exposure/interventions (e.g. type, operators, recipients, timeframes etc.) • Outcome measures – state primary and secondary outcome(s)	2
2c	**Results** - briefly describe: • Summary data with qualitative descriptions and statistical relevance, where appropriate	2
2d	**Conclusion** - briefly describe: • Key conclusions • Implications for clinical practice • Need for and direction of future research	2
INTRODUCTION		
3	**Introduction** – comprehensively describe: • Relevant background and scientific rationale for study with reference to key literature • Research question and hypotheses, where appropriate • Aims and objectives	2
METHODS		
4b	**Ethical approval** • Reason(s) why ethical approval was needed • Name of body giving ethical approval and approval number • Where ethical approval wasn't necessary, reason(s) are provided	20
4c	**Protocol** • Give details of protocol (*a priori* or otherwise) including how to access it (e.g. web address, protocol registration number etc.) • If published in a journal, cite and provide full reference	
4d	**Patient and public involvement in research** • Declare any patient and public involvement in research • State the stages of the research process where patients and the public were involved (e.g. patient recruitment, defining research outcomes, dissemination of results etc.) and describe the extent to which they were involved.	9

5a	**Study design** • State type of study design used (e.g. cohort, cross-sectional, case-control etc.) • Describe other key elements of study design (e.g. retro-/prospective, single/multi-centred etc.)	4
5b	**Setting and timeframe of research** – comprehensively describe: • Geographical location • Nature of institution (e.g. primary/secondary/tertiary care setting, district general hospital/teaching hospital, public/private, low-resource setting etc.) • Dates (e.g. recruitment, exposure, follow-up, data collection etc.)	3
5c	**Study groups** • Total number of participants • Number of groups • Detail exposure/intervention allocated to each group • Number of participants in each group	4
5d	**Subgroup analysis** – comprehensively describe: • Planned subgroup analyses • Methods used to examine subgroups and their interactions	8
6a	**Participants** – comprehensively describe: • Inclusion and exclusion criteria with clear definitions • Sources of recruitment (e.g. physician referral, study website, social media, posters etc.) • Length, frequency and methods of follow-up (e.g. mail, telephone etc.)	4
6b	**Recruitment** – comprehensively describe: • Methods of recruitment to each patient group (e.g. all at once, in batches, continuously till desired sample size is reached etc.) • Any monetary incentivisation of patients for recruitment and retention should be declared; clarify the nature of any incentives provided • Nature of informed consent (e.g. written, verbal etc.) • Period of recruitment	4
6c	**Sample size** – comprehensively describe: • Analysis to determine optimal sample size for study accounting for population/effect size • Power calculations, where appropriate • Margin of error calculation	4
METHODS - INTERVENTION AND CONSIDERATIONS		
7a	**Pre-intervention considerations** – comprehensively describe: • Preoperative patient optimisation (e.g. weight loss, smoking cessation, glycaemic control etc.) • Pre-intervention treatment (e.g. medication review, bowel preparation, correcting hypothermia/-volemia/-tension, mitigating bleeding risk, ICU care etc.)	5
7b	**Intervention** – comprehensively describe: • Type of intervention and reasoning (e.g. pharmacological, surgical, physiotherapy, psychological etc.) • Aim of intervention (preventative/therapeutic) • Concurrent treatments (e.g. antibiotics, analgesia, anti-emetics, VTE prophylaxis etc.) • Manufacturer and model details, where applicable	5
7c	**Intra-intervention considerations** – comprehensively describe: • Details pertaining to administration of intervention (e.g. anaesthetic, positioning, location, preparation, equipment needed, devices, sutures,	6

	operative techniques, operative time etc.) • Details of pharmacological therapies used, including formulation, dosages, routes, and durations • Figures and other media are used to illustrate	
7d	**Operator details** – comprehensively describe: • Requirement for additional training • Learning curve for technique • Relevant training, specialisation and operator's experience (e.g. average number of the relevant procedures performed annually)	7
7e	**Quality control** – comprehensively describe: • Measures taken to reduce inter-operator variability • Measures taken to ensure consistency in other aspects of intervention delivery • Measures taken to ensure quality in intervention delivery	7
7f	**Post-intervention considerations** – comprehensively describe: • Post-operative instructions (e.g. avoid heavy lifting) and care • Follow-up measures • Future surveillance requirements (e.g. blood tests, imaging etc.)	8
8	**Outcomes** – comprehensively describe: • Primary outcomes, including validation, where applicable • Secondary outcomes, where appropriate • Definition of outcomes • If any validated outcome measurement tools are used, give full reference • Follow-up period for outcome assessment, divided by group	5
9	**Statistics** – comprehensively describe: • Statistical tests and statistical package(s)/software used • Confounders and their control, if known • Analysis approach (e.g. intention to treat/per protocol) • Any sub-group analyses • Level of statistical significance	8
RESULTS		
10a	**Participants** – comprehensively describe: • Flow of participants (recruitment, non-participation, cross-over and withdrawal, with reasons). Use figure to illustrate. • Population demographics (e.g. age, gender, relevant socioeconomic features, prognostic features etc.) • Any significant numerical differences should be highlighted	9
10b	**Participant comparison** • Include table comparing baseline characteristics of cohort groups • Give differences, with statistical relevance • Describe any group matching, with methods	10
10c	**Intervention** – comprehensively describe: • Degree of novelty of intervention • Learning required for interventions • Any changes to interventions, with rationale and diagram, if appropriate	11
11a	**Outcomes** – comprehensively describe: • Clinician-assessed and patient-reported outcomes for each group • Relevant photographs and imaging are desirable • Any confounding factors and state which ones are adjusted	14
11b	**Tolerance** – comprehensively describe: • Assessment of tolerability of exposure/intervention • Cross-over with explanation	---

	• Loss to follow-up (fraction and percentage), with reasons	
11c	**Complications** – comprehensively describe: • Adverse events and classify according to Clavien-Dindo classification* • Timing of adverse events • Mitigation for adverse events (e.g. blood transfusion, wound care, revision surgery etc.) *Dindo D, Demartines N, Clavien P-A. Classification of Surgical Complications. A New Proposal with Evaluation in a Cohort of 6336 Patients and Results of a Survey. Ann Surg. 2004; 240(2): 205-213	4
12	**Key results** – comprehensively describe: • Key results with relevant raw data • Statistical analyses with significance • Include table showing research findings and statistical analyses with significance	16
DISCUSSION		
13	**Discussion** – comprehensively describe: • Conclusions and rationale • Reference to relevant literature • Implications for clinical practice • Comparison to current gold standard of care • Relevant hypothesis generation	17
14	**Strengths and limitations** – comprehensively describe: • Strengths of the study • Weaknesses and limitations of the study and potential impact on results and their interpretation • Assessment and management of bias • Deviations from protocol, with reasons	20
15	**Relevance and implications** – comprehensively describe: • Relevance of findings and potential implications for clinical practice • Need for and direction of future research, with optimal study designs mentioned	20
CONCLUSION		
16	**Conclusions** • Summarise key conclusions • Outline key directions for future research	20
DECLARATIONS		
17a	**Conflicts of interest** • Conflicts of interest, if any, are described	21
17b	**Funding** • Sources of funding (e.g. grant details), if any, are clearly stated • Role of funder	21
17c	**Contributorship** • Acknowledge patient and public involvement in research; report the extent of involvement of each contributor	21

The full revised STROCSS 2021 checklist

BMJ Open

Prevalence and correlates of stunting and thinness among adolescent students in Lideta sub-city, Addis Ababa, Ethiopia a cross-sectional study

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Prevalence and correlates of stunting and thinness among adolescent students in Lideta sub-city, Addis Ababa, Ethiopia: a cross-sectional study

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Abstract

Objectives: To determine the prevalence of stunting and thinness and associated factors among adolescents attending public schools in Lideta sub-city, Addis Ababa, Ethiopia, in 2021.

Design: Cross-sectional

Setting: Public schools of Lideta sub-city, Addis Ababa, Ethiopia

Eligibility: adolescents from grades 5–12 in the public schools and students whose parents gave consent for participation.

Data analysis: bivariate and multivariable logistic regression analyses were used to examine the association between the independent variables and stunting and thinness. Using a 95% confidence interval (CI) and adjusted odds ratio (AOR), factors with a p-value of less than 0.05 were determined to have a significant association.

Outcome measures: The prevalence of stunting and thinness, as well as the factors associated with stunting and thinness, were secondary outcomes.

Results: The overall prevalence of stunting and thinness was 7.2% (95% CI: 5.3–9.3%) and 9% (95% CI: 6.8–11.4%), respectively. Stunting was associated with a larger family size AOR = 3.76: 95% CI (1.58–8.94), low dietary diversity AOR = 2.87: 95% CI (1.44-5.74), food insecurity AOR = 2.81: 95% CI (1.38–5.71), and a lower wealth index AOR = 3.34: 95% CI (1.51–7.41). While thinness was associated with maternal education in those who were unable to read and write AOR = 2.5: 95% CI (1.97–8.11), inadequate dietary diversity AOR = 4.81: 95% CI (2.55–9.07), and larger family size AOR = 2.46: 95% CI (1.14-5.29).

Conclusion: Adolescent stunting and thinness were common in Addis Ababa's public schools. Family size, dietary diversity, and food security were the main factors associated with both thinness and stunting. Therefore, to decrease adolescent stunting and thinness, the government of Addis Ababa city administration should prioritize minimizing food insecurity while boosting productivity to enhance adolescent nutritional diversity. Moreover, nutritional education should be strengthened by healthcare providers working at public schools and health extension workers.

Keywords: stunting, thinness, undernutrition, adolescence, public schools, Ethiopia

Strengths and limitations of the study

- The study had a larger sample size (678) and a maximum response rate (100%).

- The study used a cross-sectional study design, which does not establish a causal relationship between the outcome variable and independent factors.
- The findings of this study might be affected by recall and social desirability bias.

Introduction

According to the World Health Organization (WHO), adolescence is defined as the period from 10 to 19 years during which an individual undergoes major physical growth, mental development, and psychological changes (1, 2). There are nearly 1.3 billion adolescents worldwide, accounting for 16% of the global population (3). Particularly in Ethiopia, children and adolescents make up around 48% of the overall population (4). Adolescents gain up to 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeletal mass as a result of increased dietary needs (5).

Suboptimal nutrition during this period leads to undernutrition, which has consequences for their health and sexual development (6). In low- and middle-income countries, malnutrition, particularly undernutrition, is very common among adolescents (7, 8). In a study that examined the global trend in 24.1 million children's nutritional status between the ages of 5 and 17 years, it was shown that the prevalence of underweight had decreased in all but South Asia, Central Africa, East Africa, and West Africa (9). Since both undernutrition and overnutrition coexist in the majority of sub-Saharan African countries, including Ethiopia, they are facing a phenomenon called the "double burden of malnutrition" (10). Moreover, the prevalence of stunting and thinness in developing nations among adolescents ranges from 32 to 48% (11, 12), particularly in Ethiopia, where it was reported to be 7.2 to 26.5% (13).

The triple burden of malnutrition includes undernutrition (underweight, stunted, or wasted), micronutrient deficiency, and overweight and obesity (weight that is greater than what is considered healthy for one's height) (14). Undernutrition in adolescence manifests as stunting and thinness, which have the potential to reduce learning capacity, delay sexual maturation, cause inattentiveness, impede academic performance, weaken physical and economic progress, restrict the body's capacity to absorb nutrients properly, and prolong poverty (15–17).

Undernutrition in adolescents is best measured by two major indicators: the low BMI (body mass index) for age, which is less than two standard deviations (SD), and stunting, which is the low

height for age, which is less than two SD (18). Adolescents' nutritional status is affected by a variety of circumstances. The key determinants are socioeconomic status, age, sex, household income, marital status, family size, maternal education, food insecurity, dietary diversity, patterns, and habits (19, 20).

Undernutrition during the adolescent period diminishes the working capacity of an individual during adulthood (21, 22). Ultimately, it silently destroys the future socio-economic development of a nation and even causes the cruel cycle of intergenerational undernutrition by causing parents to share the consequences with their children, including low birth weight, short stature, and low resistance to infection (23–25). This problem would be devastating in Ethiopia, where about 27.7% of adolescent girls become pregnant at the age of nineteen (26).

Ethiopia has been working to reduce the high burden of undernutrition through the implementation of national programs like the National Nutrition Program (NNP), including school feeding, for the past three years in Addis Ababa. As far as our knowledge is concerned, this is the first study since the start of the public-school feeding program. Therefore, the study aims to assess stunting, thinness, and associated factors among adolescents in Lideta, a sub-city of Addis Ababa, Ethiopia, in 2021.

Methods

Study area and period: The study was conducted in the Lideta sub-city of Addis Ababa, Ethiopia. The Lideta sub-city is one of the eleven sub-cities of Addis Ababa city administration, located in the central part of the town. Information obtained from the Lideta sub-city educational office reported that there were eighteen primary schools and three secondary schools. In the academic year 2020–2021, around 10,033 adolescents were registered. Of these, 3,431 were in secondary schools, and the remaining were in primary schools.

In Addis Ababa, a large-scale SFP (School Feeding Program) was launched in February 2019 with the goal of feeding kids in public elementary schools to reduce hunger in the classroom. The education bureau of the Addis Ababa municipal administration owns and funds the Addis Ababa SFP, which provides two meals for students each day (breakfast and lunch each school day). The food menu states that, throughout the course of a week, a total of eleven different food types and

items are served for both breakfast and lunch. The school lunch consists of rice, bread, marmalade, shiro-based, fir-fir, potato-based sauce, white bread (difo), injera, refined bread, tea, and boiled eggs. All of the public elementary schools in Addis Ababa provide identical school lunches (27). The study was conducted from May 20th to June 5th, 2021, using an institution-based cross-sectional study design.

Source population: all adolescent students in public schools enrolled in Lideta sub-city, Addis Ababa, Ethiopia.

Study population: all school-aged adolescents enrolled within randomly selected primary and secondary schools in Lideta Sub-City, Addis Ababa, Ethiopia.

Eligibility criteria

Inclusion criteria

Adolescents from grades 5–12 in the selected public schools and students whose parents gave consent participated in the study.

Exclusion criteria

Those public-school adolescents who were seriously ill or absent for any reason during the data collection period were excluded from the study.

Sample size determination and sampling procedure

The sample size was calculated using the single population proportion formula.

$$n = \frac{(Z\frac{\alpha}{2})^2 P(1-P)}{d^2}$$

The magnitude of stunting and thinness from the previous studies was considered 20.7 and 22% (17, 28), with a precision of 4%, a 95% confidence interval, a design effect of 1.5, and adding a 10% non-response rate, the maximum sample size was 678.

For this study, seven primary and two secondary schools were selected using simple random sampling techniques among the eighteen primary and three secondary schools that were available in the Lideta sub-city. Each school and class (grades 5–12) found in each selected school received a proportional allocation of the sample size. Each school's administrators provided a sampling

frame (a list of adolescents aged 10–19 years). Finally, a simple random sample strategy was utilized to pick study participants by using the student list as a sampling frame.

Study variables

The presence or absence of thinness as defined by having a BMI for age (BAZ) value less than two standard deviations from the WHO child growth standard and stunting as measured by a height for age (HAZ) value less than two standard deviations from the WHO child growth standard were considered as outcome variables of this study. Besides, sociodemographic characteristics such as age (10–13, 14–16, 17–19), wealth index (poor, middle, wealthy), family size (3, 4-5, >5), parents' education (unable to read and write, able to read and write, primary education, secondary education, college, and above), dietary diversity (good, poor), and environmental factors such as toilet (absence, presence) were all used as independent variables.

Data collection methods and procedures

Four diploma nurses and two BSC health officers were hired as data collectors and supervisors, respectively. Data was collected through a face-to-face interview using a structured and pre-tested questionnaire. The data collection began with the permission and consent of student parents at their residence. The parents were quizzed on sociodemographic factors, food security, wealth index, environmental sanitation, and hygiene in their home. Questionnaire-administered interviews with all of the parents (mothers or fathers) of students were conducted at their homes in the afternoon as soon as the children arrived home. The remaining individual dietary information was obtained from the adolescent.

The questionnaire for this study was adopted from the EDHS (Ethiopian Demographic Health Survey) (19) and reviewed in the literature of similar studies (7, 8, 18). The tool contains sociodemographic, nutritional, environmental, and dietary factors.

Height measurement

Setting up the measurement site

The height was measured with a stadiometer applied vertically to a hard, flat wall surface, with the base at floor level. The vertical location of the rule was checked with a carpenter's level. In the absence of such a floor, a hard wooden platform was placed beneath the high base.

Setting up the measurement site

It was measured by a weighting scale (model 8811021659, made in Germany). The weighing balance was calibrated in kilograms, and students were weighed to the nearest 0.1 kg while dressed in light clothing and without shoes.

Measuring the dietary diversity score (DDS)

The DDS was used to assess nutritional adequacy, which was defined as the number of food categories ingested in a certain period of time, often 24 hours. Each respondent was questioned about the food they had eaten the previous day, both at home and away from it. Among those who consumed at least 4 different food groups the day before, minimal dietary diversity (MDD) was obtained from 8 different food categories (24-hour recall). The DDS of eight food categories (grains (white roots, tubers, and plantains), pulses (beans, peas, and lentils), nuts and seeds, dairy and eggs, dark green leafy vegetables, vitamin-A-rich fruits and vegetables, vegetables, and fruits) was used, and it was calculated by taking into account the type and number of food groups consumed by the households (23). Poor dietary diversity was defined as a dietary diversity score below the median value (less than 4 food groups), and good dietary diversity was categorized as adolescents who had a dietary diversity score at or above the median value (greater than or equal to 4 food groups) (28).

Measuring food insecurity in households

The household food insecurity access scale (HFIAS) developed by FANTA was used to determine the level of food insecurity in the household. The scale explores the occurrence and frequency of occurrence of nine food insecurity-related events in the past 30 days of the survey. The household was classified as either food secure or food insecure by the HFIAS (29).

The wealth index procedure

Questions from the 2016 Ethiopian demographic and health survey were used to determine the wealth level of the households (19). Fourteen major variables (mobile phone, radio, chairs, tables, television, watch, jewelry, car, motorcycle, house, non-mobile telephone, refrigerator, bed with cotton, sponge, or spring mattress, and computer) were analyzed. The values of each wealth variable were recoded as 0 and 1 before undertaking principal component analysis. Scores are assigned to households based on the number and types of consumer goods they own, including each durable good, from a television to a bicycle or car, as well as dwelling qualities like bathroom amenities and flooring materials. With the help of principal component analysis (PCA), wealth

index scores were created. By giving each household a score, rating each household according to that score, and then splitting the distribution into three equal groups, each of which includes 33% of the population, the wealth quintiles were created. Following that, PCA was used to rank the findings from lowest to highest into three groups: poor, medium, and wealthy, which were coded as 1, 2, and 3, respectively.

Operational Definition:

Thinness was taken as a BMI for age (BAZ) value of less than two standard deviations from the WHO Child Growth Standard (30).

Stunting was defined as a height for age (HAZ) value of less than two standard deviations from the WHO Child Growth Standard (30).

Poor dietary diversity: adolescents with a dietary diversity score below the median value of less than 4 food groups (24).

Good dietary diversity: Adolescents were measured using a qualitative recall of all foods consumed by each adolescent during the previous 24 hours through a standardized and validated tool containing 8 food groups taken from verbal reports of the participants, and we considered an adolescent to have adequate dietary diversity if they reported consuming four or more food groups (11).

A food-secure household: A household with a score of 0–1 on the Household Food Insecurity Access Scale (HFIAS) is classified as food-secure (30).

Food insecure households: Based on an HFIAS score (0–27) of 2 and above, they were considered food insecure (31).

Quality assurance

In order to maintain the quality of the data, training was provided to data collectors and supervisors for one day by the principal investigators. The questionnaire was prepared first in English and then translated to the local language, Amharic, and back to English to check its consistency. A pretest was conducted on 5% of the subjects at Addis Ketema sub-city public schools, and the scales were carefully handled and periodically calibrated by placing standard calibration weights of 2 kg iron bars on the scales. On-site supervision was performed, and each copy of the questionnaire was checked for completeness and accuracy before data entry.

Data processing and analysis

For cleaning, recoding, and categorizing variables, the collected data was entered into EPI Info 3.1 computer programs and exported to the Statistical Package for Social Sciences (SPSS) version 21 for analysis. In addition, WHO Anthro-Plus software was used to enter and analyze anthropometric data. PCA was used to examine the household wealth index. The Keiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to verify the statistical assumptions of factor analysis. As a result, a KMO of 0.5 or above, as well as a significant Bartlett's test of sphericity (p-value of 0.05), were deemed sufficient to satisfy the assumption.

Moreover, communality values and eigenvalues of 0.5 and greater than 1 were included in the factor analysis. The variables with less than 0.5 of the communality value were removed from the analysis, and the analysis was repeated until all variables met the inclusion criteria for factor analysis. Next, all eligible factor scores were computed using the regression-based method to generate one variable, wealth status. Then, afterward, the loading factors were sorted in ascending order. Following this, the final scores were ranked into three quartiles, namely first, second, and third. Finally, ranks were interpreted as poor, medium, and wealthy, respectively. A descriptive summary (frequency distribution, proportion, mean, and standard deviation) was used to summarize the variable.

Binary logistic regression analysis was used to ascertain the association between explanatory and outcome variables. A variable whose p-value was less than 0.2 in the bivariate analysis was entered into the multivariable logistic regression analysis to determine factors associated with stunting and thinness. In the multivariable analysis, a p-value of less than 0.05 and an odds ratio with a 95% CI were used to declare the presence and strength of the association.

Patient and public involvement

Throughout the data collection period, parents or the legal guardians of the study participants and public-school teachers were involved with free support and advice for the researchers related to ethical issues and advice on how to share our findings with a wide audience in a way the public can understand.

Results

Socio-demographic characteristics of adolescents and their families

A total of 678 adolescent students were included in the study, with a 100% respondent rate. Males made up nearly half (364, or 53.7%) of the study participants. The average age of the respondents was 15 (SD 2.4) years, with a range of 11 to 19 years. Almost one third (211, or 31.6%) of the study participants were early adolescents. The majority of participants (446, or 65.8%) were from primary schools. In terms of their parents' occupation status, nearly a quarter (173 or 25.5%) of their fathers and 158 (23.3%) of their moms were government employees and housewives, respectively (Table 1).

Table 1: Sociodemographic characteristics of the study participants among adolescent students in a public school in Lideta sub-city, Addis Ababa, Ethiopia (n = 678)

Variables	Category	Frequency	Percent (%)
Sex	Male	364	53.7
	Female	314	46.3
Adolescent age	10-13	219	32.3
	14-16	296	43.7
	17-19	163	24
Adolescent grade	Primary school	446	65.8
	Secondary school	231	34.1
Fathers' educational status	Unable to read and write	77	11.4
	Able to read and write	233	34.4
	Primary education	147	21.7
	Secondary education	106	15.6
	College and above	84	12.4

Mother's education	Unable to read and write	85	12.5
	Able to read and write	147	21.7
	Primary education	167	24.6
	Secondary education	100	14.8
	College and above	80	11.8
Family size	<3	204	30.1
	4-5	217	32
	>5	257	37.9
School feeding	Yes	446	65.8
	No	232	34.2

*Primary school consists of grades five to eight, and *secondary school includes grades nine to twelve.

The dietary diversity status of adolescents

The mean (SD) dietary diversity score in the study group was 4.2 (2). The proportion of adolescents who consumed good dietary diversity was 389 (57.4%), and the proportion of adolescents who consumed poor dietary diversity was 289 (42.6%). The greater proportion of 594 (90.4%) of the study participants consumed food containing cereals, while only 187 (28% of respondents) reported consuming animal products (Table 2).

Table 2: Dietary diversity among adolescents in public schools in Lideta sub-city, Addis Ababa, Ethiopia, 2021

Variable	**Response**	**Frequency**	**Percentage**
Grains, Root or Tuber	Yes	597	88.1
	No	81	11.9

Vitamin A rich fruit and vegetable.	Yes	401	59.1
	No	277	40.9
Fruits and Vegetables	Yes	350	48.4
	No	328	51.6
Meat, poultry, offal and Fish	Yes	193	28.5
	No	485	71.5
Eggs (eggs)	Yes	199	70.6
	No	479	29.4
Pulses, Legumes, nuts and seeds	Yes	257	37.9
	No	421	62.1
Milk& milk products	Yes	296	43.7
	No	382	56.3
Food cooked Oils and Fats	Yes	532	78.5
	No	146	21.5

*Vitamin A-rich fruits and vegetables include red, yellow, and green leafy vegetables like carrots, cabbage, sweet potatoes, mango, and papaya.

Wealth index and food security status of households

Regarding household food security measurement, the study participants were asked to report the frequency of worrying about what to eat and the range of remaining hungry day and night in the previous four weeks before the survey. Based on the nine HFIAS questions' responses, their frequencies of occurrence over the past 30 days were assessed. As a result, more than half (381, or 56.2%) of the households were food secure, and 297, or 43.8 percent, were food insecure.

Moreover, according to wealth classification, 231 (34.1%) of households had poor assets, while 207 (30.5%) and 240 (35.4%) were classified as medium-asset and rich-asset households, respectively.

Adolescent eating habits and frequency

The adolescents' eating habits were analyzed based on the adolescents' and their parents' reports on their meal frequency; subsequently, 348 (52.2%) of the adolescents consumed meals three times per day, while 36.1% of the respondents did not eat meat once a week. while the vast majority of adolescents (92.2%) eat injera at home. Almost half of the students (45%) do not consume fruit on a weekly basis (Table 3).

Table 3: Eating habits and frequency among adolescents in public schools of Lideta sub-city, Addis Ababa, 2021

Variable	Category	Frequency	Percentage
Meal frequency	Once a day	12	1.8
	Twice a day	190	28
	Three times a day	323	47.6
	More than four times	152	22.6
Frequency of meat eating in week	Never	134	19.8
	Once a week	166	24.5
	Twice a week	152	22.4
	Three times a week	117	17.5
	More than three times a week	109	16
Soft drinks in one week	Never	160	23.3
	Once a week	136	20.1
	Twice a week	180	26.5
	Three times a week	78	11.5
	More than three times a week	104	15.3

Drink citrus fruit, in week	Never	138	20.4
	Once a week	172	25.4
	Twice a week	256	37.8
	More than twice per week	112	16.5
Eating egg in week	Never	263	38.8
	Once a week	95	14
	More than twice a week	175	28.5
	Every day	143	21.4
Drink Milk and milk products in week	Never	235	34.7
	Once a week	185	27.3
	More than twice a week	125	18.4
	Once a day	133	19.6
Staple food in the family	Injera	495	72.7
	Bread	154	22.7
	Other	31	4.5

Prevalence of stunting and thinness among adolescents in public schools

The overall prevalence of stunting and thinness among adolescents was 49 (7.2%) (95% CI (5.3–9.3%)) and 61 (9%) (95% CI (6.8–11.4%), respectively (figure 1). Thinness was more common among adolescents aged 17–19 years (11%), compared with age groups 14–16 years (8.8%) and 10–13 years (7.8%). Similarly, stunting was more prevalent among 17–19-year-old adolescents (9.8%), whereas it was 8.2 and 5.1% among 10–13 and 14–16-year-olds, respectively. Besides, thinness was more than two times as common and stunting was nearly four times as prevalent among school-age adolescents from food-insecure households compared with their counterparts, and the proportions of thinness and stunting among adolescents who had poor dietary diversity were 15.9 and 12.5%, respectively. Based on sex category, both thinness and stunting were higher among males (11% and 8.5%, respectively) compared with females (Table 4).

Table 4: Proportion of thinness and stunting in relation to different variables in adolescents in public school students of Lideta sub-city, Addis Ababa, 2021

Variables	Thinness		Stunting	
	Yes	No	Yes	No
Sex				
Male	40 (11%)	324 (89%)	31 (8.5%)	333 (91.5%)
Female	21 (6.7%)	293 (93.3%)	18 (5.7%)	296 (94.3%)
Age group				
10-13	17 (7.8%)	202 (92.2%)	18 (8.2%)	201 (91.8%)
14-16	26 (8.8%)	270 (91.2%)	15 (5.1%)	281 (94.9%)
17-19	18 (11.0%)	145 (89.0%)	16 (9.8%)	147 (90.2%)
Food security				
Secured	22 (5.8%)	359 (94.2%)	12 (3.1%)	369 (96.9%)
Insecured	39 (13.1%)	258 (86.9%)	37 (12.5%)	260 (87.5%)
Wealth index				
Poor	26 (11.3%)	205 (88.7%)	31 (13.4%)	200 (86.6%)
Middle	18 (8.7%)	189 (91.3%)	9 (4.3%)	198 (95.7%)
Wealthy	17 (7.1%)	223 (92.9%)	9 (3.8%)	231 (96.2%)
Dietary diversity				
Good	15 (3.9%)	374 (96.1%)	13 (3.3%)	376 (96.7%)
Poor	46 (15.9%)	243 (84.1%)	36 (12.5%)	253 (87.5%)

Factors associated with stunting among adolescents

The bivariate regression analysis indicated that sex, family size, the mother's occupation, dietary diversity, household food insecurity, and the wealth index were associated with stunting. While, in multivariable analysis, family size, individual dietary diversity, household food insecurity, and wealth index were statistically and independently associated with stunting,

Adolescents with a family size of more than five had a nearly four-times higher risk of stunting than those with a family size of less than three [AOR = 3.764; 95% CI = (1.583–8.94)]. Similarly, participants who were food insecure at the household level were three times more likely to be stunted [AOR = 2.804; 95% CI = (1.378–5.706)]. Furthermore, the chances of stunting were three times higher among participants with poor dietary diversity compared with their counterparts [AOR = 2.870; 95% CI (1.435–5.741)]. The odds of stunting were also higher among adolescent students from poor families [AOR = 3.343; 95% CI (1.51–7.41)] (Table 5).

Table 5: Bivariate and multivariable logistic regression analysis for stunting among adolescent students in Lideta sub-city, Addis Ababa, 2021

Variables	Stunted		COR (95% CI)	AOR (95% CI)	P-value
	Yes	No			
Sex					
Male	31 (4.6%)	333 (49.1%)	1.51 (.282-2755)	1.316 (.307-5.631)	.556
Female	18 (2.7%)	296 (43.4%)	1	1	
Family size					
<3	7 (1%)	197 (29.1%)	1	1	
4-5	9 (1.3%)	208 (30.7%)	1.862 (.844- 4.106)	1.113 (.396-3.125)	.839
>5	33 (4.9%)	224 (33%)	2.759 ((1.32-5.75)	**3.77 (1.583-8.948)**	.003**
Mother occupation					
House wife	19 (3%)	140 (21.9%)	3.046 (1.33-6.929)	1.358 (.455-4.052)	.583

Daily laborer	6 (0.9%)	73 (11.4%)	1.845 (.635-5.363)	.979 (.252-4.128)	.977
Governmental	10 (1.6%)	129 (20.2%)	1.740 (.688-4.398)	2.002 (.583-6.876)	.270
Non-government	4 (0.6%)	46 (7.2%)	1.952 (.576-6.614)	1.257 (.190-8.312)	.813
Self-employ	9 (1.4%)	202 (31.7%)	1	1	
House hold food security status					
Food secure	12 (1.8%)	369 (54.4%)	1	1	
Food insecure	37 (5.5%)	260 (38.3%)	4.376 (2.239-8.553)	**2.804 (1.378-5.706)**	.004**
Individual dietary diversity score					
Good dietary	13 (1.9%)	376 (55.5%)	1	1	
Poor dietary	36 (5.3%)	253 (37.3%)	4.116 (2.14-7.914)	**2.870 (1.435-5.741)**	. 005**
Wealth Index					
Poor	31 (4.5%)	200 (29%)	3.978 (1.850-8.557)	**3.343 (1.510-7.403)**	.001**
Middle	9 (1.3%)	198 (29.2%)	1.178 (.454-2.998)	1.190 (.450-3.142)	.726
Wealthy	9 (1.3%)	231 (34.1%)	1	1	

Reference category: significant at a p–value of <0.05*, significant at a p–value of <0.01**

Factors associated with thinness among adolescent students

A bivariate analysis revealed that sex, family size, mother's education, father's career, individual dietary diversity, household food security, and wealth index were all related to thinness. Multivariable analysis, however, showed that family size, mother education, and individual dietary diversity were statistically and independently related to thinness after controlling for confounding variables. Accordingly, adolescents from families with a family size of more than five were nearly 2.4 times more likely than those with a family size of less than three to acquire thinness [AOR = 2.458, 95 percent CI: (1.140–5.296)].

Similarly, the odds of being thin were three times higher among participants whose mothers were not able to read and write compared with participants whose mothers had a college diploma and above [AOR = 2.59; 95% CI (1.969–8.003)]. Individuals with insufficient dietary diversity had a

nearly five-fold higher risk of being thin than their peers [(AOR=4.812:95 percent CI (2.552–9.072)] (table 6).

Table 6: Bivariate and multivariable analysis of thinness among adolescents in public school students of Lideta sub-city, Addis Ababa, 2021

Variables	Thinness		COR (95% CI)	AOR (95% CI)	p-value
	Yes	No			
Sex					
Male	40 (5.9%)	324 (47.8%)	1.72 (.993-2.989)	1.29 (.675-2.77)	.439
Female	21 (3.1%)	293 (43.2%)	1	1	
Family size					
<3	10 (1.5 %)	194 (28.6%)	1	1	
4-5	19 (2.8%)	198 (29.2%)	1.86 (.844-4.106)	1.607 (.707-3.64)	.257
>5	32 (4.7%)	225 (33.2%)	2.76 (1.32-5.75)	**2.45 (1.140-5.29)**	.022*
Mother Education					
Unable to read and write	12 (1.9%)	73 (11.6%)	3.18 (1.05-9.54)	**2.593 (1.969-8.03)**	0.05*
Able to read and write	9 (1.4%)	138 (21.8%)	1.36 (.473-3.923)	2.401 (.758-7.612)	.137
Primary education	15 (2.4%)	152 (24.1%)	1.51 (.535-4.212)	2.377 (.765-7.380)	.134
Secondary education	16 (2.5%)	117 (18.5%)	1.13 (.356-3.593)	2.387 (.342-7.706)	.146
College and above	5 (0.8%)	95 (15%)	1	1	
HHFS					
Food secure	22 (3.2%)	359 (52.9%)	1	1	
Food insecure	39 (5.8%)	258 (38.1%)	2.47 (1.42-4.261)	1.43 (.767-2.66)	.260
Individual dietary diversity					

Good dietary	15 (2.2%)	374 (55.2%)	1	1	
Poor dietary	46 (6.8%)	243 (35.8%)	4.72 (2.578-8.64)	**4.812 (2.55-9.07)**	. 001**
Wealth Index					
Poor	26 (3.8%)	205 (30.2%)	1.66 (.877-3.155)	1.39 (.668-2.925)	.374
Middle	18 (2.7%)	189 (27.9%)	1.25 (.626-2.492)	1.18 (.523-2.660)	.691
Wealthy	17 (2.5%)	223 (32.9%)	1	1	

Reference category: significant at a p–value of <0.05*, significant at a p–value of <0.01**

Discussion

The current study's findings revealed that the prevalence of stunting and thinness was higher in male and older adolescents than in younger ones. The results were consistent with those of another study done in southern and central Ethiopia (32, 33). A possible explanation for the reason behind this might be due to the fact that those young adolescents participate in the school lunch program. Overall, 7.2% of adolescents in public schools in Lideta, a sub-city of Addis Ababa, were stunted. When compared to a study report from Brazil (6%) (34) and Kenya (6.5%) (35), this result was higher. Differences in socioeconomic, cultural, and seasonal factors could explain the difference. However, this result was lower than those of research conducted in Damot Sore District, Southern Ethiopia (29.6%) (32) and in Adama City, Central Ethiopia (21.3%) (33). This disparity could be explained by a difference in income between the two research areas and study periods. Adolescents in Addis Ababa were more likely to have access to food, nutrition information, and educated households than those in Ambo and Adama City. Moreover, there has been a school feeding program in Addis Ababa since 2019.

School adolescents who lived in households with five members or more were nearly four times more likely to be stunted than school adolescents who lived in households with three members. A study conducted in Dale, southern Ethiopia; Axum Town, northern Ethiopia; and Indonesia backed up the findings (35–37). This could be due to the large number of family members sharing the limited food, resulting in insufficient food consumption and stunting. Furthermore, when family

size increased, per capita human inputs declined, which could be explained by a larger dependency ratio, resulting in poorer nutritional consumption among adolescent students.

Adolescents with poor dietary diversity were three times more likely to be stunted than their counterparts. This finding was consistent with a report from Dangila, western Ethiopia; Rabat, Morocco; and India (22, 38, 39). This could be explained by the fact that, in a phase of rapid growth and development, poor dietary diversity and irregular food intake are less likely to meet adolescents' nutritional requirements. As a result, failure to provide adequate food for daily body demand would result in stunting.

Household food insecurity was found to be significantly linked to stunting, with adolescents from food-insecure families were roughly three times more likely to have stunting than those from food-secure families. This finding was supported by data from Jimma, Southwest Ethiopia, the Somali Region, eastern Ethiopia, and a meta-analysis from developing regions (21, 40, 41). The possible explanation for this could be high market and food inflation, which may have negatively impacted the food security situation of urban households, in addition to seasonal variations within and across countries. As a result, adolescents may have reduced food intake, consumed poor-quality diets, or disrupted eating patterns, which can ultimately lead to stunting.

Adolescents from poor families were three times more stunted than those from wealthy families. This conclusion was backed up by research conducted in the Gurage zone, Ethiopia (42), Axum, northern Ethiopia (36), and Bihar, India (25). This could imply that the nutritional status of teenagers is solely determined by the socioeconomic position of the households in which they live. This further results in insufficient dietary quality and quantity due to the inability to purchase a variety of foods and eating preferences. Furthermore, adolescents from low-income households may have less access to and utilization of health care than those from wealthy families.

Thinness was found to be prevalent in 9% of the study populations. This finding was consistent with a study conducted in Debark, Northern Ethiopia, which reported 10.3% (43) and yawned, Cameroon reported 9.5% (44). However, it was lower than studies in Mekelle City, northern Ethiopia, at 26.1% (14), Western Kenya, at 15.6% (45), and India, at 20% (46). This gap could be attributable to the implementation of nutrition intervention programs in Addis Ababa public schools by state and nongovernmental organizations. Furthermore, cultural differences and socioeconomic disparities may play a role.

The odds of being skinny were 2.5 times greater among participants whose mothers couldn't read or write compared to participants whose mothers had a college diploma or higher educational standing. This result was similar to those found in Adwa, Ethiopia (47), Assam, India (42), and Adama, Ethiopia (34). This could be due to the mother's low level of education, a lack of nutrition knowledge, or the fact that they are not formally educated and cannot understand different promotions. As a result, her decision-making ability and contribution to the total family income will be limited. It could also have an impact on the type of food that is made and supplied.

Adolescents from households with more than five individuals were 2.4 times thinner than those from households with fewer than three members. Axum Town in North Ethiopia (36) and Riyadh, Saudi Arabia (48), have both reported similar occurrences. This could be due to the numerous household members sharing the available food and increased competition for food, which could impair both the quality and amount of food served at home, resulting in insufficient food consumption and thinness.

When it comes to dietary diversity, adolescents with insufficient nutritional diversity were 4.8 times thinner than those with substantial dietary diversity. This result was similar to those reported in Karnataka, India (35), and Axum, Ethiopia (36). This could be attributed to a lack of nutritional diversification and irregular meals.

Limitation

The current study is cross-sectional in design, which does not establish a causal relationship between the outcome variable and independent factors. In addition, we utilized a 24-hour recall to account for the number of food categories ingested that might be affected by recall and social desirability bias.

Conclusion and recommendation

Adolescent stunting and thinness were common. Thinness was connected to parental education, family size, and individual dietary diversity. Stunting was also linked to household income, family size, food insecurity, and dietary diversity. Therefore, to decrease adolescent undernutrition, the government of Addis Ababa city administration should prioritize minimizing food insecurity while boosting productivity to enhance adolescent nutritional diversity. Moreover, nutrition education should be strengthened by healthcare providers working at public schools and health extension workers.

Declaration

Ethical consideration

The researchers secured ethical approval from Kotebe University of Education, Menelik II Medical and Health Science College's research and ethical review board with reference number ID KUE/38/12/3027. Official letters were obtained from the Addis Ababa health bureau, and an authorization letter was provided by the Lideta sub-city educational office. Following a thorough explanation of the study objectives to the adolescent parents or legal guardians, the data of the adolescent students was collected after having their informed written consent.

Consent for publication

Not applicable

Data Availability

The datasets used to support the findings of this study are attached with the manuscript.

Conflicts of interest

The author declares they have no competing conflicts of interest.

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Author contributions

AA: This author made substantial intellectual contributions to the conception, design, and acquisition of data, analysis, and interpretation. EA: has contributed to conception, design, and data interpretation. TS: This author contributed to the study design, analysis, and gave approval of

the final version to be published, and GKG: has been involved in the analysis and interpretation of data, drafting the manuscript, and revising it critically for important intellectual contents.

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Figure 2: Adolescent stunting and thinness in public schools of Lideta sub-city, Addis Ababa, Ethiopia 2021

The STROCSS 2021 Guideline		
Item no.	**Item description**	**Page**
TITLE		
1	**Title** • The word cohort or cross-sectional or case-control is included* • Temporal design of study is stated (e.g. retrospective or prospective) • The focus of the research study is mentioned (e.g. population, setting, disease, exposure/intervention, outcome etc.) *STROCSS 2021 guidelines apply to cohort studies as well as other observational studies (e.g. cross-sectional, case-control etc.)	1
ABSTRACT		
2a	**Introduction** – briefly describe: • Background • Scientific rationale for this study • Aims and objectives	2
2b	**Methods** - briefly describe: • Type of study design (e.g. cohort, case-control, cross-sectional etc.) • Other key elements of study design (e.g. retro-/prospective, single/multi-centred etc.) • Patient populations and/or groups, including control group, if applicable • Exposure/interventions (e.g. type, operators, recipients, timeframes etc.) • Outcome measures – state primary and secondary outcome(s)	2
2c	**Results** - briefly describe: • Summary data with qualitative descriptions and statistical relevance, where appropriate	2
2d	**Conclusion** - briefly describe: • Key conclusions • Implications for clinical practice • Need for and direction of future research	2
INTRODUCTION		
3	**Introduction** – comprehensively describe: • Relevant background and scientific rationale for study with reference to key literature • Research question and hypotheses, where appropriate • Aims and objectives	2
METHODS		
4b	**Ethical approval** • Reason(s) why ethical approval was needed • Name of body giving ethical approval and approval number • Where ethical approval wasn't necessary, reason(s) are provided	20
4c	**Protocol** • Give details of protocol (*a priori* or otherwise) including how to access it (e.g. web address, protocol registration number etc.) • If published in a journal, cite and provide full reference	
4d	**Patient and public involvement in research** • Declare any patient and public involvement in research • State the stages of the research process where patients and the public were involved (e.g. patient recruitment, defining research outcomes, dissemination of results etc.) and describe the extent to which they were involved.	9

5a	**Study design** • State type of study design used (e.g. cohort, cross-sectional, case-control etc.) • Describe other key elements of study design (e.g. retro-/prospective, single/multi-centred etc.)	4
5b	**Setting and timeframe of research** – comprehensively describe: • Geographical location • Nature of institution (e.g. primary/secondary/tertiary care setting, district general hospital/teaching hospital, public/private, low-resource setting etc.) • Dates (e.g. recruitment, exposure, follow-up, data collection etc.)	3
5c	**Study groups** • Total number of participants • Number of groups • Detail exposure/intervention allocated to each group • Number of participants in each group	4
5d	**Subgroup analysis** – comprehensively describe: • Planned subgroup analyses • Methods used to examine subgroups and their interactions	8
6a	**Participants** – comprehensively describe: • Inclusion and exclusion criteria with clear definitions • Sources of recruitment (e.g. physician referral, study website, social media, posters etc.) • Length, frequency and methods of follow-up (e.g. mail, telephone etc.)	4
6b	**Recruitment** – comprehensively describe: • Methods of recruitment to each patient group (e.g. all at once, in batches, continuously till desired sample size is reached etc.) • Any monetary incentivisation of patients for recruitment and retention should be declared; clarify the nature of any incentives provided • Nature of informed consent (e.g. written, verbal etc.) • Period of recruitment	4
6c	**Sample size** – comprehensively describe: • Analysis to determine optimal sample size for study accounting for population/effect size • Power calculations, where appropriate • Margin of error calculation	4
METHODS - INTERVENTION AND CONSIDERATIONS		
7a	**Pre-intervention considerations** – comprehensively describe: • Preoperative patient optimisation (e.g. weight loss, smoking cessation, glycaemic control etc.) • Pre-intervention treatment (e.g. medication review, bowel preparation, correcting hypothermia/-volemia/-tension, mitigating bleeding risk, ICU care etc.)	5
7b	**Intervention** – comprehensively describe: • Type of intervention and reasoning (e.g. pharmacological, surgical, physiotherapy, psychological etc.) • Aim of intervention (preventative/therapeutic) • Concurrent treatments (e.g. antibiotics, analgesia, anti-emetics, VTE prophylaxis etc.) • Manufacturer and model details, where applicable	5
7c	**Intra-intervention considerations** – comprehensively describe: • Details pertaining to administration of intervention (e.g. anaesthetic, positioning, location, preparation, equipment needed, devices, sutures,	6

	operative techniques, operative time etc.) • Details of pharmacological therapies used, including formulation, dosages, routes, and durations • Figures and other media are used to illustrate	
7d	**Operator details** – comprehensively describe: • Requirement for additional training • Learning curve for technique • Relevant training, specialisation and operator's experience (e.g. average number of the relevant procedures performed annually)	7
7e	**Quality control** – comprehensively describe: • Measures taken to reduce inter-operator variability • Measures taken to ensure consistency in other aspects of intervention delivery • Measures taken to ensure quality in intervention delivery	7
7f	**Post-intervention considerations** – comprehensively describe: • Post-operative instructions (e.g. avoid heavy lifting) and care • Follow-up measures • Future surveillance requirements (e.g. blood tests, imaging etc.)	8
8	**Outcomes** – comprehensively describe: • Primary outcomes, including validation, where applicable • Secondary outcomes, where appropriate • Definition of outcomes • If any validated outcome measurement tools are used, give full reference • Follow-up period for outcome assessment, divided by group	5
9	**Statistics** – comprehensively describe: • Statistical tests and statistical package(s)/software used • Confounders and their control, if known • Analysis approach (e.g. intention to treat/per protocol) • Any sub-group analyses • Level of statistical significance	8
RESULTS		
10a	**Participants** – comprehensively describe: • Flow of participants (recruitment, non-participation, cross-over and withdrawal, with reasons). Use figure to illustrate. • Population demographics (e.g. age, gender, relevant socioeconomic features, prognostic features etc.) • Any significant numerical differences should be highlighted	9
10b	**Participant comparison** • Include table comparing baseline characteristics of cohort groups • Give differences, with statistical relevance • Describe any group matching, with methods	10
10c	**Intervention** – comprehensively describe: • Degree of novelty of intervention • Learning required for interventions • Any changes to interventions, with rationale and diagram, if appropriate	11
11a	**Outcomes** – comprehensively describe: • Clinician-assessed and patient-reported outcomes for each group • Relevant photographs and imaging are desirable • Any confounding factors and state which ones are adjusted	14
11b	**Tolerance** – comprehensively describe: • Assessment of tolerability of exposure/intervention • Cross-over with explanation	---

	• Loss to follow-up (fraction and percentage), with reasons	
11c	**Complications** – comprehensively describe: • Adverse events and classify according to Clavien-Dindo classification* • Timing of adverse events • Mitigation for adverse events (e.g. blood transfusion, wound care, revision surgery etc.) *Dindo D, Demartines N, Clavien P-A. Classification of Surgical Complications. A New Proposal with Evaluation in a Cohort of 6336 Patients and Results of a Survey. Ann Surg. 2004; 240(2): 205-213	4
12	**Key results** – comprehensively describe: • Key results with relevant raw data • Statistical analyses with significance • Include table showing research findings and statistical analyses with significance	16
DISCUSSION		
13	**Discussion** – comprehensively describe: • Conclusions and rationale • Reference to relevant literature • Implications for clinical practice • Comparison to current gold standard of care • Relevant hypothesis generation	17
14	**Strengths and limitations** – comprehensively describe: • Strengths of the study • Weaknesses and limitations of the study and potential impact on results and their interpretation • Assessment and management of bias • Deviations from protocol, with reasons	20
15	**Relevance and implications** – comprehensively describe: • Relevance of findings and potential implications for clinical practice • Need for and direction of future research, with optimal study designs mentioned	20
CONCLUSION		
16	**Conclusions** • Summarise key conclusions • Outline key directions for future research	20
DECLARATIONS		
17a	**Conflicts of interest** • Conflicts of interest, if any, are described	21
17b	**Funding** • Sources of funding (e.g. grant details), if any, are clearly stated • Role of funder	21
17c	**Contributorship** • Acknowledge patient and public involvement in research; report the extent of involvement of each contributor	21

The full revised STROCSS 2021 checklist