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Overweight and Obesity and Associated Factors among Adolescent Students in Public Day Secondary Schools in Machakos County, Kenya

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ABSTRACT

Background: Overweight and obesity have increased significantly worldwide, placing major economic problems on health systems. This study aims to determine socio-economic characteristics, dietary practices, physical activity levels, nutrition status, predictors of overweight and obesity, and their relationships among adolescents. **Methods:** The study adopted a cross-sectional analytical study design. 401 adolescents were randomly selected from five secondary day schools using a proportionate-to-size sampling method. **Results:** Based on the findings, one third (36.3%) of the adolescents were between ages 17-18, with more girls (55.9%) than boys. The number of meals consumed per day among adolescents was 3.34±1.24. Individual dietary diversity score among adolescents was 4.21±1.61. Based on Body Mass Index (BMI), the prevalence of overweight and obesity among boys was 5.2% and 1.8%, respectively, and for girls, it was 7.3% and 3.6%, respectively. Using bioelectrical impedance analysis, the prevalence rates for males were 8.8% and 4.1%, respectively, while for females the rates were 10.1% and 5.1%. Regression analysis revealed that the most significant predictors were energy intake and physical activity, with $P<0.05$ based on BMI and bioelectrical impedance analysis. **Conclusion:** There is a significant relationship between nutritional status and energy intake, the number of meals, dietary diversity score, and physical activity. Physical activity and dietary practices were the most important predictors of overweight and obesity among adolescents. The study recommends nutrition education and public health interventions in schools' curricula.

Introduction

Overweight/obese means an unnecessary increase in body fat, creating harmful health consequences. Being overweight and obese predisposes one to non-communicable diseases and is considered the fifth leading risk factor for killer diseases worldwide (Lobstein *et al.*, 2015). Studies have shown that 10% of children and adolescents are overweight or obese worldwide (De Schutter *et al.*, 2014). The causes of overweight and obesity include genetics, physical inactivity, and excess energy intake (Akinlade *et al.*, 2014).

Obesity is a risk factor for insulin resistance,

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hypertension, atherosclerosis, some cancers, gallbladder disease, disabilities, and decreased quality of life in adolescents (Sylvetsky-Meni *et al.*, 2015). Obese adolescents are prone to stigmatization and low self-esteem (Ashdown-Franks *et al.*, 2019, Caleyachetty *et al.*, 2018). Students in public day secondary schools in Kisumu, Kenya, were more likely to suffer from obesity or being overweight due to low physical activity and high-fat, sugar, and salt diets (Okoth *et al.*, 2015).

Many studies have shown that for overweight and obesity prevention, people should modify their eating practices and physical activity (Williamson *et al.*, 2020). The results of a cross-sectional study in designing an effective intervention program may increase obesity prevention among adolescents (Towner *et al.*, 2015). Data on adolescents' overweight/obesity is limited in Kenya (Hüls *et al.*, 2021). Therefore, this study aims to assess the predictors of nutritional status among adolescent students in public day secondary schools in Machakos Sub-County.

Materials and Methods

Research design and participants

The researcher adopted a cross-sectional analytical design method. This study was conducted in Machakos Sub-County, Machakos County. No research has been done on adolescents' overweight in Machakos County (Towner *et al.*, 2015). The adolescent students (13-19) attending public day secondary schools in Machakos Sub-County. This study only included boys and girls aged 13-19 attending public day secondary schools in Machakos Sub-County. The study excluded students who were sick, were transferred from other counties six months before the commencement of the study, and those who did not sign the consent forms to contribute to the study.

Sample size and sampling

The required sample size was calculated based on the standard formula by Cochran (1963) as cited by Fisher (Fisher *et al.*, 1998) as $n=(Z^2.pq)/d^2$. Finally, 401 adolescences randomly were selected.

Data collection

The questionnaire was administered to the students at school in classrooms. The informed verbal consent was obtained in the classroom from each respondent. After that, the Physical Activity Questionnaire for Adolescents (PAQ-A) was administered. Dietary intake data was gathered through a food frequency questionnaire and the 24-Hour Recall Questionnaire. The 24-hour recall comprised inquiring the respondents to report on the entire food and drink intake for the preceding 24 hours (the previous day), from foods consumed for breakfast in the morning to the last foods at night before bed.

From a list of 12 regularly consumed food groups, a seven-day food frequency questionnaire was used to gather information on the frequency of consumption in the preceding seven days. Individual dietary diversity score was done using individual dietary diversity score (IDDS) composed of 12 food groups. It was adapted to assess the quality and variety of the diet consumed by the household members, emphasizing the adolescent students by adding the number of food groups they consumed in the last 24 hours into scores.

Anthropometric measurements of weight, height, and body fat percentage were collected. Weight was measured using a bathroom scale (VON model HMSB 13 CB) to the nearest 100 grams calibrated at the beginning of each session. Stadiometer was used to measure height to the nearest 0.1 centimeters. The participants were measured while standing straight with their backs on the height board mounted on the wall. The BIA scale (Beurer model BF 750) measured body fat. Students were asked to remove shoes and socks or any heavy clothing; then, body fat was taken twice for each student and was recorded. Finally, the mean value was calculated.

Data analyses

Except for the 24-hour recall data, all other data were entered and analyzed using the SPSS computer software version 20. Data from 24 hours recall and food frequency was analyzed using

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Nutri- Survey for windows (2007). WHO AnthroPlus software was applied to analyze anthropometric data in z-scores for those under 18 and their body mass index (BMI) (Epi-Info), which was then exported to SPSS. The indicators of overweight and obesity used were BMI above 25 kg/m² for overweight and BMI above 30 kg/m² for obesity. For BIA indicator, male overweight adolescents were categorized as 17.1-22% and female overweight adolescents as 23.1-30%. Obesity for male adolescents was classified as >22.1%, whereas for female adolescents, it was >30.1% (Jebb, 2004). The data on physical activity were categorized into very little, little, moderate, often, and very often, per PAQ-A guidelines. Then, using SPSS, chi-square was used to measure associations between physical activity levels and overweight/obesity. Multiple logistical regression analysis was done to determine how overweight/obesity is predicted by physical activity and dietary practices, and thus identify the significant predictors in the study population. Significance levels were then determined at a 95% confidence interval, and a P-value of < 0.05 was used.

Results

About 44.1% of the students included in the study were male, and 55.9% were female. About 35.3% of the students were between 15-16, with mean ± SD age of 16.55±1.8 (**Table 1**). Over half (68%) of households comprised four to six members. Most adolescent students lived with their parents (74.7%), and 72.9% of their parents were married. Most adolescent parents/guardians (54.4%) had completed secondary education. Most of the teenage students' parents/guardians (37.4%) were entrepreneurs, with 27.8% of parents/ guardians depending on farming. The majority (67%) of the households involved in the study obtained food by purchasing from the market, and 31.2% got food from their farm production. Over half (55.9%) of the participants consumed three meals daily: breakfast, lunch at school, and supper at home. On average, the study population consumed 3.34±1.24 meals a day.

Table 1. Demographic and socio-economic characteristics, number of meals consumed by adolescent students

Variable	N=388	%
Gender		
Male	171	44.1
Female	217	55.9
Age(years)		
13-14	53	13.7
15-16	137	35.3
17-18	141	36.3
>19	57	14.7
Education level		
1	98	25.3
2	71	18.3
3	126	32.5
4	93	24.0
Number of meals normally per day		
Two	121	31.2
Three	217	55.9
Four	37	9.5
Five	13	3.4

The study result indicated that cereals were most regularly consumed at school and home (up to 6 days by 88.1%). Over 95% consumed sugar/sweets for ≥ 6 days. An oil/fat-rich diet for ≥ 6 days was consumed in a week by 84.5% of respondents (**Table 2**).

The respondents consumed a mean IDDS of 4.21±1.61. About a third of the respondents consumed five food groups (37.9%), with half (50.8%) not meeting the recommended number of at least five food groups daily. The study results showed that 88.3% of boys and 92.4% of girls met the recommended daily allowance (RDA) for energy (**Table 3**).

There was a significant difference in the physical activity levels of male and female adolescents (P<0.05) throughout the week, with females being less active than male adolescents (**Table 4**).

Judged by BMI for age z-scores, 81.5% of the total participants (had a normal weight, 6.4%, were overweight, and 2.3%, were obese (**Table 5**). Based on BIA, 81.3% of male adolescents had normal weights, while 8.8% were overweight and 4.1% were obese. As for the female adolescents,

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74.7% were of normal weight, 10.1% overweight, and 5.1% were obese (**Table 5**). Based on BMI for age z-scores, most participants of different ages were of normal weight. Those who were 13-14 (7.5%) and 19 (8.8%) were overweight. The obese were 17-18 (4.3%) and 19 (3.5%, **Table 6**). There were significant relationships between nutritional status as measured by BMI and BIA with household income, gender, number of meals, energy intake, dietary diversity score, and physical activity level ($P<0.05$, **Table 7**). Regression analysis was conducted to assess the relationship between dependent variables (BMI and BIA) and independent variables, dietary intake and physical activity. Both energy intake and physical activity were the most significant predictors of overweight and obesity based on BMI and BIA with $P<0.05$ (**Table 8**).

Discussion

This study documented that the majority (54.4%) of the adolescent student's parents/guardians had completed secondary education. Low educational level limits their ability to engage in professional occupations, ending up doing small-scale businesses. Similarly, a study in Tanzania also reported that adolescent fathers (54.8%) and mothers (38%) had secondary education levels with low-socio-economic backgrounds (Tluway *et al.*, 2018).

A study in Ghana found that adolescents from low or high socioeconomic status were either overweight/obese, with the majority staying within the town (Amoh and Appiah-Brempong, 2017). These results were consistent with the findings in research from Nigeria, which also found that obesity/overweight existed among adolescents staying near town who were from low and high social classes (Pediatric project, 2016). This study found similar results. The research findings established that the participants' occupation, expenditure on food, and location influenced obesity and overweight.

Table 2. Number of times various food groups were consumed among adolescents at Machakos Sub-County.

Variable	Times a week					
	=<2		3-5		6	
	N	%	N	%	N	%
Cereals	3	0.77	43	11.0	342	88.1
Pulses, legumes & nuts	35	9.0	105	27.0	248	63.9
Meat	85	21.9	229	59.0	74	19.0
Fish	201	51.8	185	47.6	2	0.5
Eggs	95	24.4	237	61.0	56	14.4
Green leafy and other vegetables	24	6.1	77	19.8	287	73.9
Fats and oils	7	1.8	53	13.6	328	84.5
Fruits	67	17.2	137	35.3	184	47.4
Tubers/roots	42	10.8	257	66.2	89	22.9
Milk and milk products	15	3.8	49	12.6	324	83.5
Sugar /sweets	4	1.0	2	3.09	372	95.8
Spices /condiments	7	1.8	303	78.0	78	20.1

Table 3. Nutrient intake among the adolescents at Machakos Sub-County.

Nutrient	Recommended daily allowance		Mean intake		% of adequate intake	
	Male	Female	Male	Female	Male	Female
Energy (Kcal)	3000	2200	3124±218	2314±271	88.3	92.4
Protein (g)	59	44	62.4±4.5	53.4±5.7	75.2	79.3
Carbohydrates(g)	130	130	148.3±12.9	141.3±9.5	92.4	94.2
Fat (g)	16	11	17.5±0.68	14.3±0.84	91.5	95.8

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Table 4. Participation in physical activity level over 5 days period among adolescents at Machakos Sub-County .

	Physical activity															P- value[b]
	Very little			Little			Moderate			Often			Very often			
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	
Mon	10 (5.8)	29 (13.4)[a]	22 (5.7)	51 (29.8)	62 (28.6)	200 (51.5)	52 (30.4)	60 (27.6)	118 (30.4)	40 (23.4)	40 (18.4)	35 (9.0)	18 (10.8)	26 (11.9)	13 (3.4)	<0.001
Tue	12 (7.0)	27 (12.4)	10 (2.6)	47 (27.5)	58 (26.7)	204 (52.6)	50 (29.2)	59 (27.2)	120 (30.9)	40 (23.4)	38 (17.5)	38 (9.8)	22 (12.9)	35 (16.1)	16 (4.1)	<0.001
Wed	10 (5.8)	25 (11.5)	23 (5.9)	51 (29.8)	65 (29.9)	207 (53.4)	49 (28.7)	62 (28.6)	114 (29.4)	37 (21.6)	39 (17.9)	29 (7.5)	24 (14.0)	26 (11.9)	15 (3.9)	<0.003
Thur	23 (13.5)	20 (9.2)	31 (7.9)	49 (28.1)	69 (31.8)	198 (51.0)	43 (25.1)	60 (27.6)	116 (29.9)	42 (24.6)	38 (17.5)	30 (7.7)	14 (8.2)	30 (13.8)	13 (3.4)	<0.001
Fri	19 (11.1)	22 (10.1)	15 (3.9)	50 (29.2)	68 (31.3)	203 (52.3)	38 (22.2)	65 (29.9)	124 (31.9)	46 (26.9)	32 (14.7)	34 (8.8)	18 (10.5)	30 (13.8)	12 (3.1)	<0.001

[a]: n(%); [b]:ANOVA test.

Table 5. Nutritional status of the adolescent students by sex based on body mass index and bioelectrical impedance analysis at Machakos Sub-County.

Variable	Male		Female		Total	
	N	%	N	%	N	%
Category /Based on body mass index						
Underweight	14	8.2	24	11.1	38	9.8
Normal	145	84.8	169	78	316	81.5
Overweight	9	5.2	16	7.3	25	6.4
Obese	3	1.8	8	3.6	9	2.3
Category /Based on bioelectrical impedance analysis						
Underweight	10	5.8	22	10.1	32	8.2
Normal	139	81.3	162	74.7	301	77.6
Overweight	15	8.8	22	10.1	37	9.5
Obese	7	4.1	11	5.1	18	4.6

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Table 6. Nutritional status of adolescent students by age (year) based on body mass index at Machakos.

Weight status	Age groups							
	13-14		15-16		17-18		19	
	N	%	N	%	N	%	N	%
Underweight	15	28.5	12	8.8	9	6.4	2	3.5
Normal	34	64.0	117	85.4	117	83.0	48	84.2
Overweight	4	7.5	7	5.1	9	6.4	5	8.8
Obese	0	0.0	1	0.7	6	4.2	2	3.5

Table 7. Relationships between demographic and socio-economic characteristics and overweight/obesity status of the adolescent students at Machakos Sub-County.

Variable	Body mass index		Bioelectrical impedance analysis	
	Statistical test	P-value	Statistical test	P-value
Demographic and socio-economic characteristics				
Household income	Pearson=0.20	0.014	Pearson=0.62	0.009
Gender	Chi- square	0.013	Chi- square	0.011
Dietary practices				
Number of meals	Pearson=0.43	0.016	Pearson=0.53	0.012
Energy intake	Pearson=0.64	0.005	Pearson=0.67	0.0091
Individual dietary diversity score	Pearson=0.31	0.007	Pearson=0.35	0.006
Physical activity	Pearson=0.56	0.021	Pearson=0.57	0.001

Table 8. Multiple linear regressions showing how energy intake and physical activity predict body mass index and bioelectrical impedance analysis among adolescent students at Machakos Sub-County.

Variable	Body mass index		Bioelectrical impedance analysis	
	B	P-value	B	P-value
Energy	0.012	0.002	0.009	0.031
Physical activity	-0.024	0.001	0.011	0.021
R^2	<0.001		<0.001	

Discussion

This study documented that the majority (54.4%) of the adolescent student's parents/guardians had completed secondary education. Low educational level limits their ability to engage in professional occupations, ending up doing small-scale businesses. Similarly, a study in Tanzania also reported that adolescent fathers (54.8%) and mothers (38.0%) had secondary education levels with low-socio-economic backgrounds (Tluway *et al.*, 2018).

A study in Ghana found that adolescents from low or high socioeconomic status were either overweight/obese, with the majority staying within the town (Amoh and Appiah-Brempong, 2017). These results were consistent with the findings in research from Nigeria, which also found that obesity/overweight existed among adolescents staying near town who were from low and high social classes (Pediatric project, 2016). This study found similar results. The research findings established that the participants' occupation, expenditure on food, and location influenced obesity and overweight.

This study indicated that all the students obtained their lunch from school. Diet source in this study influenced their diet intake leading to a low prevalence of overweight /obesity among adolescents. Similarly, studies in Nigeria and Kenya indicated the source of diet for adolescent

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students, which influences the frequency of food consumption and the number of meals taken daily. Ready access to foods may lead to a sufficient/ excessive nutrient intake. These affect adolescents' nutritional status (Pediatric project, 2016). Most day school students eat the lunch prepared at school (Bereket *et al.*, 2017, Okoth *et al.*, 2015). The 24-hour recall collected information regarding the number of meals consumed by the respondent daily. Regular and adequate meals among adolescents help them meet their increased nutrient requirements for emotional, physical, and psychological growth (Kumah *et al.*, 2015). In this study, more than half (55.9%) of the adolescents consumed three meals daily, with few consuming snacks. The schools only provided lunch daily and snacks one to two days a week. This led to a higher number of normal weights and a lower prevalence of overweight/obesity. This was in contrast to US and European studies, where most overweight and obese adolescents consumed at least four meals and more than two snacks daily (Garrido-Miguel *et al.*, 2017, Ogden *et al.*, 2014). The study findings revealed that students who were overweight and obese consumed more significant food portions for lunch in school which were rich in cereals, legumes, and fats/oils daily in the seven days, with consumption of meat and eggs for less than three days a week. Increased sugar intake was significantly associated with overweight and obesity. The outcomes of this research were in agreement with the results of a study conducted in rural parts of Machakos county, Kenya, that found most communities in the rural areas frequently consumed cereals and cereal products, sweetened beverages, fats/oils, and sugar food groups (Ndolo, 2019).

A study showed a high cereal, fats, and sugar intake among overweight adolescents (Gebrie *et al.*, 2018). The majority of the adolescent students cited that local production (31.2%) and low market prices (67.0%) were primary reasons for the moderate consumption of leafy green vegetables and fruits (47.4%). The average consumption of fruits and vegetables was significantly related to the low prevalence of overweight and obesity among the students. The result of this study was in agreement with a study in Nigeria in which 56.5% consumed fruits, and in contrast, fewer adolescents (15.0%) consumed vegetables (Lateef *et al.*, 2016). Other studies in Tanzania similarly reported adolescents' low fruit and vegetable intake (Chinenere, 2014, Nakiranda, 2015).

The dietary diversity score effectively obtained data on the number of food groups' intake by participants daily. In this study, 37.9% of adolescents consumed about five food groups out of twelve. A similar study in Kenya, Nigeria, and Ethiopia indicated cases of skipping meals by adolescents due to food insecurity ((Pediatric project, 2016). In this study, less than half of the students consumed five food groups, with the majority consuming less than five food groups daily.

The study found that most adolescents met the RDA for energy, fat, carbohydrates, and protein requirements. Similarly, the outcomes of this study were supported by the research carried out in Nigeria in which most of the respondents assessed consumed proteins, energy, fats, and carbohydrates adequately (Adebusoye *et al.*, 2021). In this study, higher percentages of normal BMI were reported as 84.8% for males, and 78.0% for females and for normal BIA, it was 81.3% for males, and 74.7% for females.

This study indicated that 51.5% of the adolescents had little physical activity, and 30.4% had moderate physical activity. On the other hand, very few (3.4%) were involved in physical activity very often. These findings agreed with the study's results in Kenya and Nigeria, which indicated that most adolescents in rural areas were more active compared to those in urban areas who were overweight and had low physical activity levels (Adeniyi *et al.*, 2016). Physical inactivity among students in this study contributed to overweight and obesity.

In this study, based on BMI for age, 6.4% of adolescents were overweight, while 2.3% were obese. These outcomes are related to a study conducted in South Africa in which the prevalence of overweight and obesity among teenagers in day

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high schools were 5.7% and 3.8%, respectively based on BMI for age (Rossouw *et al.*, 2012).

BMI and BIA were used in this study to measure obesity levels. However, they were not the gold standard for estimating obesity/overweight but have been used before in further studies (Wan *et al.*, 2014). Studies found BIA to be more precise in giving higher percentages of obesity than BMI (Kamanu, 2019). BMI is at its best in measuring fatness but does not differentiate fat from muscles, bones, and lean body mass (Ganu, 2019). So, this means a person can have a healthy BMI but still have excess fats around the stomach, which can increase the possibility of heart disease, high blood pressure, and type 2 diabetes (Craig *et al.*, 2014).

The prevalence of overweight and obesity was higher based on BIA; 8.8% of the male adolescents and 10.1% of the females were overweight, and 4.1% of males and 5.1% of females were obese. In this study, the prevalence of overweight and obesity by BMI was consistent with past studies compared to BIA (Okoth *et al.*, 2015, Wan *et al.*, 2014).

Overall, the most significant predictors of overweight and obesity in this study using BMI and BIA were energy intake and physical activity, with a P-value of <0.05. These results were similar to a study in Kenya, where the most significant predictors of overweight and obesity among adolescents were increased energy intake and physical activity (Jimoh, 2016). A study in Kenya observed that increased energy intake predicted overweight and obesity compared to other factors among adolescents, similar to the results of this study (Fongar *et al.*, 2019).

As in other studies, in this study, the researchers observed a difference in prevalence regarding sex in overweight/obesity, where girls experienced a higher prevalence than boys (Muhihi *et al.*, 2012, Rossouw *et al.*, 2012). The study findings reported an association between parental education and occupation status and overweight or obesity using BMI (P=0.014) and BIA (P=0.009) among adolescents, as has been reported in other school-based studies in urban Tanzania, Kenya, Ghana, and Brazil (Amidu *et al.*, 2013, Diouf *et al.*, 2018, Mwaikambo *et al.*, 2015). The hypothesis that there was no significant association between socioeconomic characteristics and overweight and obesity was rejected.

A study in Indonesia reported that intake of energy involving excessive consumption of refined sweets, sugars, refined foods, and fats was associated with overweight/obesity using BMI (P=0.003) among Indonesian adolescents (Oddo *et al.*, 2019). Similarly, these findings revealed that increased intake of sugar and refined cereals high in energy was linked to overweight/obese students using BMI (P=0.005) in the study.

A study in Kenya observed that most adolescent students usually consumed fewer fruits and vegetables, which was highly linked to an increased prevalence of overweight and obesity (Kanaiza, 2016). In contrast, this study noted a moderate intake of fruits and vegetables that was significantly linked to a low prevalence of overweight and obesity among adolescents. Students who exceeded RDA for energy, fat, carbohydrates, and proteins were overweight and obese in this study. The study results aligned with the findings conducted in Ethiopia and Kenya, which established that dietary practice might be positively and negatively associated with adolescent students' nutritional status (Gali *et al.*, 2017).

A study in Kenya pointed out that physical inactivity among adolescents was significantly associated with overweight and obesity using BMI (P=0.006) and BIA (P=0.031) (Ssewanyana *et al.*, 2018). Similarly, this study observed that overweight and obese students were prevalent among most adolescents regarding little or moderate physical activity. Therefore, there was a significant relationship between physical activity and overweight/obesity using BMI (P=0.021) and BIA (P=0.001). The finding of this study agreed with and confirmed several studies that found overweight and obesity were associated with physical activity levels (Bereket *et al.*, 2017, Matsudo *et al.*, 2016, Pediatric project, 2016).

The accessibility of students at schools provided easy contact for the respondents, a major strength

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for the study. In addition, Kenyatta University and the schools provided the necessary infrastructure, materials and equipment required for the study. However, the assessment of dietary practices was limited to a recall of food consumed, thus an estimated rather than the actual measurement.

Conclusion

In the present study, most male and female adolescents met RDA for energy, proteins, carbohydrates, and fat. The level of physical activity by students was low. The probability of females being overweight and obese was higher than their male counterparts. The most significant predictors of overweight and obesity were increased energy intake and low physical activity. Significant relationships existed between nutritional status and gender, energy intake, number of meals, dietary diversity score, and physical activity. It is also recommended that other studies be conducted in other semi-urban areas in Kenya to acquire sufficient information on diet intake patterns, physical activity levels, and nutritional status among adolescents in public day secondary and private secondary schools.

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Ethics approval and consent to participate

A permit and ethical clearance were obtained from Kenyatta University. Research permit was obtained from National Council for Science, Technology, and Innovation. Research authorization was given from the county commissioner, the Sub- County director of education, and respective school principals. Informed verbal consent was obtained from each respondent before leading the interview. The investigator assured respondents that involvement in the study was voluntary, and that confidentiality was guaranteed.

Conflict of interests

The authors declared no conflict of interests.

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The authors supported this research.

Authors' contributions

Ndanu Kyalo M designed the experiment, collected and, analyzed the data, and wrote the manuscript. Chege P and Kamuhu R read, corrected, and approved the manuscript. All authors read and approved the final version of the manuscript.

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