Original Research Article

Relationship between Anthropometric and Serum parameters of Adolescent School Children aged 10 – 19 years in upland and riverine public secondary schools in Rivers state

Abstract

The study assessed the relationship between anthropometric and serum parameters of adolescent school children aged 10 – 19 years in upland and riverine public secondary schools in Rivers state. Four hundred and eighteen (418) adolescents were randomly selected from 4 secondary schools, two each from the upland and riverine areas for the study. Standard procedures were used to obtain data for all parameters. Serum from forty subjects was used for biochemical analysis. Data collected was analysed using statistical product and service solution (SPSS) for windows version 25. Data obtained was presented as frequencies, percentages, Pearson correlation was used to determine the relationship between variables and significance accepted at $p \leq 0.05$.Significant correlation exist between BMI and haemoglobin in the upland ($r = 0.364$) and in the riverine area ($r = 0.819$) at $p<0.05$.While a positive correlation was observed between WHR and serum zinc in the Riverine ($r = 0.731$) at $p<0.05$, and a negative correlation exists between WHR and serum calcium in the Upland ($r = -0.421$) area at $p<0.05$. MUAC showed a positive correlation with Haemoglobin in the Upland ($r = 0.452$) at $p<0.05$. Triceps ($r = -0.818$) and sub-scapula ($r = -0.747$) skinfolds both showed negative correlations with serum zinc in the Riverine area at $p<0.01$ and $p<0.05$ respectively.Nutrition education and counseling are essential in secondary schools to reduce malnutrition among adolescent school children.

Keywords: Assessment Anthropometric Biochemical Parameters Adolescent School Children

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Introduction

Malnutrition among children and adolescents is a major public health concern with increasingly significant causes of disability and premature death globally. Adolescents are risk group for malnutrition, but they are often not part of a target in many interventions.It is found that foods frequently consumed by adolescents do not meet the minimum required energy and nutrient needs for their age (Obsequio-Namoco, 2016).This has resulted in the prevalence of diet related diseases in the adolescent population (Oludare, 2015;Mezie-Okoye and Alex-Hart, 2015). Food nutrients ingested and assimilated should be reflected in the blood from where it is utilized for proper body functioning and development. Blood nutrient level depicts nutrient supply to the body and functionality of the body system, which is mirrored by the growth and development of the individual. Adolescence is a period of transition occasioned by the onset of puberty. Onset of puberty and its associated body changes is highly uneven and does not progress with chronological age (Mitchell, 2003). For an individual, puberty may start at age 10 and for another it can start at age 13. Irrespective of the time of onset of puberty, nutritional needs are very high due to the changes that occur during each phase (early: 10 to 13years, middle: 14 to 16years and late: 17 to 19years) of the adolescence period (Mitchell, 2003). There is paucity of nutritional data on adolescent school children in Rivers state. Rivers state is one of the 36 states in Nigeria with communities defined by the amount of water bodies in their locations to either upland (fewer water bodies) or riverine (fewer land mass) areas. Hence this study seeks to assess the relationship between the some anthropometric indices and serum parameters of adolescent school children in public secondary schools in Rivers state. Specifically the study: (i) assessed body mass index, mid upper arm circumference, triceps and subscapula skinfold measurements and waist-hip-ratio of the subjects, (ii) serum calcium, iron, zinc, heamoglobin and ferritin levels of the subjects, and (iii) assessed the relationship between anthropometric measures and serum parameters of the subjects.

Materials and methods

The study was carried out in Rivers state among four hundred and eighteen (418) adolescent school children randomly selected from 4 public secondary schools, two each from the upland and riverine areas respectively for the study. Ethical clearance for this study was obtained from Rivers State Ministry of Health. Informed consent was obtained in writing from parents/guardians of the 40 adolescents school childrenused for biochemical assessment during preliminary visit between researcher and parents/guardian. Only healthy school children were used for the study. Standard procedures were used to obtain data for anthropometric and biochemical assessments. Blood from forty (40) subjects was used for biochemical analysis.

Anthropometry

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Body mass index of the subjects was calculated from their weight and height measurements using the formula: Body Mass Index = weight (kg) / height (m^2), and classified thus:

thinness or low BMI-for-age – values <5th percentile, andoverweight or high BMI-for-age – values >85th percentile (WHO,1995).

Mid upper arm circumference (MUAC) was taken on the left arm with the hand hanging freely at the side of the trunk with palm facing the thigh. The tape was placed around the upper arm, midway between the acromion process (bony tip) of the scapula and the Olecranon process (the point of the elbow). Measurement was taken to the nearest 0.1 cm. Two readings were taken at site of measurement, and then the mean calculated and recorded. Values <5th percentile or >95th percentile are indicators for nutritional intervention (WHO, 1995).

Waist hip ratio (WHR) of the subjects was obtained from their waist and hip measurements using the formula: WHR = Waist circumference (cm) / Hip circumference (cm). Values were classified thus: values <0.95 (males) and <0.80 (females) indicates low health risk. Values between 0.96 – 1.0 (male) and 0.81 – 0.85 (females) indicate moderate health risks, while values above 1+ (males) and 0.85+ (females) indicate high health risk (WHO, 2008).

The triceps skinfold was taken at mid-point between the acromion and olecranon processes. Two readings were taken at the site of measurement, and then the mean calculated and recorded. Subscapula skinfold measurement was taken at 20 mm below the tip of the Scapula, at an angle of 45^0 to the lateral side of the body. Skinfold thickness was measured at the left side of the body to the nearest 0.1 mm using a skinfold caliper. One skinfold rater was used to reduce inter- rater error. Triceps and subscapula skinfold values below the 10th percentile indicates low fat stores (underweight) while values higher than the 90th percentile indicates higher fat stores a tendency of becoming obese in future (WHO, 1995).

Biochemical assessment

Blood collection was between 8am – 10am on the day of collection.Blood samples (5ml) were collected by venipuncture using either the antecubital vein or the dorsal vein and dispensed into labelled lithium heparin anticoagulant bottles and placed in a cooler stalked with ice block prior

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to when they were sent to the laboratory for analysis. Blood samples collected from each subject were sent to the laboratory the same day they are collected.

Serum calcium level was determined by atomic absorption spectrometry as described by Cali, Mandel and Moore (1972).Calcium values between 9 – 11mg/dl were considered as normal (FDA, 2015).

Serum zinc was determined by colorimetric method described by Makino and Saito (1982); Homster and Zak (1985).Serum levels 70 -120 µg/dl was defined as normal, Serum level < 70µg/dl for females defines deficiency while serum level< 74µg/dl for males defines deficiency (IZiNCG, 2004).Haemoglobin was analysed using cyanmethaemoglobin method (Carter, 1971).

Haemoglobin level less than 115 – 120g/L in children 10 – 14 years and older female adolescents indicate deficiency while values less than 130g/L for males indicate deficiency (WHO 2006).

Serum Iron was analyzed using spectrophotometric method as described by Darcie and Lewis (1984).Serum iron level less than 15 µg/L indicate iron deficiency (WHO, 2006).

Serum ferritin was determined using atomic absorption spectroscopy. Cutoff value of <15µg/l indicate deficiency (WHO, 2006).

Data collection

Anthropometric data was collected using a non-stretch tape graduated to the nearest 0.1cm for measurement of circumferences, flat bathroom scale graduated in kilogram for weight measurement, a portable stature meter graduated to the nearest 0.1cm for height measurement, and a skinfold caliper graduated to the nearest 0.2mm for skinfold measurement. While 5ml of subjects blood was collected for biochemical assay.

Data analysis

Data collected was analysed using statistical product and service solution (SPSS) for windows version 25. Data obtained was presented as frequencies, percentages, Pearson correlation was

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used to determine the relationship between anthropometric and biochemical variables, and statistical significance was accepted at $p \leq 0.05$.

Result

Anthropometric assessment of Subjects

Body mass index (BMI-for-age) of majority of the respondents was normal (Upland 71.5%), Riverine 66.7%). In the Upland (22.1%) were thin and in the Riverine (29.5%) were thin. Majority of the respondents in the Upland (63.5%) and Riverine (82.1%) areas have normal MUAC-for-age. About 30percent of respondents in the Upland were underweight, and 6.5% overweight. In the Riverine area, 11.5percent and 6.5percent of the respondents were underweight and overweight respectively. Significant difference (p=0.0000) exist between the MUAC-for-age of respondents in the Upland and Riverine areas.Triceps skinfold measurement of the respondents showed that 59.4percent (Upland) and 56.4percent (Riverine) have low fat stores. Also 40.6percent in the Upland and 43.6percent in the Riverine areas, have high fat stores.The result showed a significant difference (p=0.0001) between triceps skinfold of the respondents in the Upland and Riverine areas. Sub-scapula skin foldmeasurement of the respondents showed that 68.2percent in the Upland and 65.4percent in the Riverine have high fat stores.Chi Square result showed no significant difference (p=0.491) between the Sub-scapula skinfold of respondents in the Upland and Riverine areas. Waist-hip-ratio of the respondents showed that 55.6%, 22.9% and 21.5% in the Upland have low, moderate and high risks of cardiovascular diseases respectively. While in the Riverine area, 62.8%, 28.2% and 9.0% are at low, moderate and high risksof cardiovascular diseases respectively. Chi Square comparison showed a significant difference (p=0.000) between WHR of Upland and Riverine adolescents.

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Table 1: The Anthropometric indices of adolescents in the study area

Anthropometric indices	Upland				Riverine			
	Age group in years				Age group in years			
Body mass index	**10-13yrs**	**14 – 16yrs**	**17 – 19yrs**	**Total**	**10-13yrs**	**14 – 16yrs**	**17 – 19yrs**	**Total**

(BMI-for-age)								
Thin (low BMI-for-age values ≤ -2SD or < 5th percentile)	25(7.4)	26(7.6)	24(7.1)	75(22.1)	8(10.3)	8(10.3)	7(9.0)	23(29.5)
Normal (18.5 -24.9)	82(24.1)	80(23.5)	81(23.8)	243(71.5)	13(16.7)	17(21.8)	22(28.2)	52(66.7)
Overweight (high BMI-for-age) values ≥ +1SD or > 85th percentile	3(0.9)	3(0.9)	0(0.0)	6(1.8)	-	-	-	-
Obese (BMI-for-age) ≥ + 2SD or > 95th percentile	4(1.2)	8(2.4)	4(1.2)	16(4.7)	2(2.6)	1(1.3)	0(0.0)	3(3.8)
MUAC-for-age								
Underweight values < 5th percentile	48(14.1)	39(11.5)	15(4.4)	102(30.0)	2(2.6)	1(1.3)	6(7.7)	9(11.5)
Normal	65(19.1)	74(21.8)	77(22.5)	216(63.5)	20(25.6)	24(30.8)	20(25.6)	64(82.1)
Overweight values > 90th percentile.	1(0.3)	4(1.2)	17(5.0)	22(6.5)	1(1.3)	1(1.3)	3(3.8)	5(6.4)
				X^2=33.695, df=4. P=0.000				
Triceps skinfold (TCSF-for-age)								
Low fat stores / underweight (TCSF-for-age values < 10th percentile)	76(22.4)	77(22.6)	49(14.4)	202(59.4)	16(20.5)	13(16.7)	15(19.2)	44(56.4)
High fat stores (obese) TCSF-for-age values > 90th percentile	38(11.2)	40(11.8)	60(17.6)	138(40.6)	7(9.0)	13(16.7)	14(17.9)	34(43.6)
				X^2=13.753,df=2,p=0.0001				
Sub-scapula skinfold (SSSF-for-age)								
Low fat stores/ underweight/thin (values <10th percentile)	39(11.5)	43(12.6)	33(9.7)	115(33.8)	12(15.4)	6(7.7)	9(11.5)	27(34.6)
High fat stores (obese) values >90th percentile	75(22.1)	74(21.8)	76(22.4)	225(66.2)	11(14.1)	20(25.6)	20(25.6)	51(65.4)
				X^2=1.422 df=2 ,p=0.491				
WHR								
Low risk	52(15.3)	60(17.6)	77(22.6)	189(55.6)	5(6.4)	22(28.2)	22(28.2)	49(62.8)
Moderate risk	28(8.2)	30(8.8)	20(5.9)	78(22.9)	13(16.7)	3(3.8)	6(7.7)	22(28.2)
High risk	34(10.0)	27(7.9)	12(3.5)	73(21.5)	5(6.4)	1(1.3)	1(1.3)	7(9.0)
				X^2 =27.621,df=4, p=0.000				

F (%) – Frequency (percentage), WHR –Waist hip ratio, MUAC – Mid upper arm circumference

Biochemical assessment of serum from subjects

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Serum Calcium levels across the three age categories (Table 2) in the Upland area shows 50.0%, 28.1% and 21.9% each as above normal, normal and low calcium levels respectively. While in the Riverine area, 75.0%, 12.5% and 12.5% each were above normal, normal and low levels respectively.The result showed that significant difference exists (p=0.010) between the serum calcium levels of subjects in the Upland and Riverine area.

Serum iron levels for both Upland and Riverine areas where low (<15µg/L) across the three age categories.

Serum zinc levels of the subjects in both Upland and Riverine areas were low (<70 µg/L for female &<74 µg/L for male) across the three age categories.

Haemoglobin levels of the subjects in the Upland had 62.5% normal (≥12 g/dl) and 37.5% mild anaemia (10-11.9 g/dl). In the Riverine area, a similar trend occurs with 62.5% normal levels (≥12 g/dl) and 37.5% mild anaemia (10-11.9 g/dl). No significant difference exist between the haemoglobin levels of the Upland and Riverine respondents with p=0.060.

The Ferritin levels of the respondents across the three age categories in both Upland and Riverine areas were normal. Ferritin values were ≥15µg/l.

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Table 2: Biochemical assessment serum calcium, serum iron, serum zinc, hemoglobin, and ferritin) of the subjects n =40

Biochemical indices	Upland				Riverine			
	Age group in years				Age group in years			
Serum Calcium	10-13yrs	14 – 16yrs	17 – 19yrs	Total	10-13yrs	14 – 16yrs	17 – 19yrs	Total
Low	5(15.6)	2(6.3)	0(0.0)	7(21.9)	1(12.5)	0(0.0)	0(0.0)	1(12.5)
Normal	0(0.0)	4(12.5)	5(15.6)	9(28.1)	0(0.0)	0(0.0)	1(12.5)	1(12.5)
Above normal	5(15.6)	5(15.6)	6(18.8)	16(50.0)	1(12.5)	3(37.5)	2(25.0)	6(75.0)
				X2=13.364a,df=4,p=0.010				
Serum Iron								
Low deficiency (< 15µg/L)	10(31.3)	11(34.4)	11(34.4)	32(100.0)	2(25.0)	3(37.5)	3(37.5)	8(100.0)
Normal	-	-	-	-	-	-	-	-
Serum Zinc								
Low(<70 µg/L for female & <74 µg/L for male)	10(31.3)	11(34.4)	11(34.4)	32(100.0)	2(25.0)	3(37.5)	3(37.5)	8(100.0)
Hemoglobin								
Mild anaemia (10-11.9 g/dl)	6(18.9)	4(12.6)	2(6.3)	12(37.5)	1(12.5)	2(25.0)	0(0.0)	3(37.5)
Normal (≥12 g/dl)	4(12.5)	7(21.9)	9(28.1)	20(62.5)	1(12.5)	1(12.5)	3(37.5)	5(62.5)
				X2=5.613a,df=2,p=0.060				
Ferritin								
Normal (≥ 15µg/L)	10(31.3)	11(34.4)	11(34.4)	32(100.0)	2(25.0)	3(37.5)	3(37.5)	8(100.0)

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Relationship between anthropometric and biochemical parameters.

The results in Table 3 showed a positive significant correlation between BMI and haemoglobin in the upland (r = 0.364) and in the riverine area (r = 0.819) at p<0.05.While a positive and significant correlation was observed between WHR and serum zinc in the riverine (r = 0.731) at p<0.05, and a negative correlation exists between WHR and serum calcium in the upland (r = -0.421) area at p<0.05. MUAC showed a positive significant correlation with Haemoglobin in the upland (r = 0.452) at p<0.05. Triceps (r = -0.818) and sub-scapula (r = -0.747) skinfolds both showed negative but significant correlations with serum zinc in the riverine area at p<0.01 and p<0.05 respectively

Table 3: Relationship between Anthropometric and Biochemical parameters of the subjects

Location		BMI	WHR	MUAC	Triceps	Sub-Scapula
Upland	Serum Calcium	0.134	-0.421*	0.094	0.033	-0.051
	Serum Iron	0.032	-0.109	0.032	-0.276	-0.299
	Serum Zinc	0.033	-0.077	-0.175	-0.258	-0.271
	Hemoglobin	0.364*	-0.214	0.432*	0.243	0.339
	Ferritin	-0.214	0.133	-0.129	-0.092	-0.124
Riverine	Serum Calcium	0.257	0.480	0.106	-0.554	-0.338
	Serum Iron	-0.228	0.401	-0.170	-0.382	-0.486
	Serum Zinc	0.185	0.731*	-0.329	-0.838**	-0.747*
	Hemoglobin	0.819*	-0.259	0.391	-0.072	0.181
	Ferritin	0.651	0.279	0.197	-0.195	-0.034

** - correlation is significant at $p \leq 0.01$ (2 tailed)
* - Correlation is significant at $p \leq 0.05$ (2 tailed)
BMI- Body mass index,
WHR – Waist –hip-ratio,
MUAC- Mid upper arm circumference

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Discussion

Anthropometric indices of the respondents

Body mass index (BMI)-for- age for majority of the respondents in this study was within the normal range (18.5 – 24.9) in both upland (71.5%) and riverine (66.7%) areas. This finding is in agreement with studies of Donald-Ase and Afam-Anene (2022) who reported normal BMI for majority of their subjects (87.4%) in their study of Adolescents anthropometric indices, food choices and eating habits in secondary schools in Bayelsa state. The present study also showed that 22.1 and 29.5 percent's of adolescents in upland and riverine areas respectively were thin (BMI-for-age < 5th percentile). This trend is similar to findings of Donald-Ase and Afam-Anene (2022) who reported 11.4percent thin, (BMI < 5th percentile) among their study participants. Despite the fact that majority of the participants in this study had normal weight, those that were thin BMI-for-age < 5th percentile (upland 22.1%, riverine 29.5%), if this figure is projected into the larger population of adolescents in the state, will show a very high proportion of thin adolescents which will impact negatively on both the health and nutritional status of the state. Thinness is a global public health concern which negatively affects an individual's health and productivity in life.

The mid upper arm circumference (MUAC) of the subjects in this study was mostly within the normal range for both upland (63.5%) and riverine (82.1%) areas. This is not far-fetched as studies have shown MUAC to correlate directly with BMI (Lillie et al. 2019; Sisay et al., 2022) as can be seen in the similarity of the BMI and MUAC results of this study. Findings in this study also showed underweight (MUAC-for-age < 5th percentile) for 30.0 and 11.5 percent's of adolescents in the upland and riverine areas respectively. This finding is similar to that of Lillie, Lema, Kaaya, Steinberg and Baumgartner (2019) who reported similar trend in the MUAC of their subjects, with 25% of their study subjects been underweight (MUAC < 5th percentile). MUAC is a certified indicator of under-nutrition in children. Significant difference exist between the mean MUAC-for-age of adolescents in upland and riverine (.X2=33.695, df=4. P=0.000) areas.

Triceps skinfold thickness of the subjects showed lower fat stores (values <10th percentile), indicating underweight among 54.9% in the upland and 56.4% in the riverine areas. This finding corroborates with the MUAC of this study which indicated underweight in 30.0 and 11.5 percent

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of the subjects in this study. These findings indicate underweight within half of the study population as given by the triceps values. The tendency to be obese (values >90th percentile, high fat stores) was also observed in 40.6 and 43.6 percent's of the respondents in both upland and riverine areas respectively. This finding buttresses the need for nutrition education among adolescents in the study area. The increase in triceps skinfold measurement with age among the subjects of this study differs from studies of Soylu, et.al (2021), who reported decrease in triceps with age among both sexes until it peaks at age 12years in boys, before a gradual decline is observed. The mean triceps value of this study were closer to those recorded by Otitoola et. al, (2021), who recorded mean triceps skinfold of 8.80mm (female) and 4.94mm (males) in their study of prevalence of overweight and obesity among selected school children and Adolescents 6 – 18 years in Cofimvaba South Africa.

The mean subscapula skinfold measurement of the participants in this study showed most of the subjects in both upland (66.2%) and Riverine (65.4%) areas to have high fat stores (values >90th percentile, indicative of been obese). The mean subscapula skinfold range across upland and riverine areas was between 5.04mm to 7.66mm. This differs from Soylu et al (2021) who reported mean values of 17.2 to 16.5mm in boys, and 18.9 to 26.8mm in girls. This difference could be due to geographical location that affects body composition. Although subscapula skinfold measurements differ in both studies, an agreement was observed to exist between both studies that subscapula skinfold thickness increases with age.

The two skinfold sites measured in this study reflects differences in subcutaneous fat deposits at both sites. Triceps indicating underweight while subscapula skinfold indicating obesity. This is not farfetched as literature has shown that changes in subcutaneous fat (skinfold thicknesses) occur at different sites of measurement, and that subcutaneous fat at one site may not reflect fat stores at another site (Eaton-Evans, 2013).

The waist-hip-ratio (WHR) of subjects in this study showed that 55.6percents and 62.8percents of the subjects from the upland and the riverine areas respectively, were within lower risk of developing conditions that relate to cardiovascular diseases. The WHR of subjects in this study (WHR 0.83 – 0.92) differs slightly from that of Jasanya et.al, (2018), who reported total WHR of 0.84 for their subjects. This difference could be due to geographical factors which affects body composition of individuals. The result of this study also showed some subjects from upland

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(22.9%) and riverine (28.2%) to be at moderate risk, and 21.5percent from the upland area to be at high risk of developing cardiovascular diseases. This finding reveals the need for urgent nutritional intervention in the form of nutrition education and nutrition counseling. A significant difference exist between the WHR of the upland subjects and the riverine subjects ($p<0.05$).

A significant positive correlation was observed between BMI and haemoglobin (Hb) in both upland ($r = 0.364$, $p =0.05$), and riverine ($r = 0.819$, $p = 0.05$) areas as shown in Table 3. Findings of this study agrees with that of Acharya et.al, (2018), who studied the correlation of haemoglobin versus BMI and body fat in young adult female medical students, and observed an association between BMI and Hb. Although a negative association was observed in their study which differed from the positive association observed between BMI and haemogliobin in this study can be explained that, the subjects of this study were of both sexes while those of Achatya et al (2018) were only females, who are prone to monthly blood loses than males. Body mass development is subject to proper functioning and transportation of oxygen to body cells of which haemoglobin is vital. In a similar study, Gligoroka et.al, (2020) observed a significant positive correlation ($r = 0.32$) between haemoglobin and body mass index while studying red blood cell variables and correlation with body mass components in boys aged 10 – 17 years. These findings implies that normal haemoglobin status affect body mass index positively in adolescence, and this further emphasizes the importance of consuming iron rich food in adolescence. A significant positive but moderate correlation was observed between haemoglobin and MUAC ($r = 0.432$, $p<0.05$) in this study. This is not far from other studies that have shown that Hb level increase by 0.11g/dl with each centimeter increase in MUAC in girls (Ahankari et.al, 2020). The findings of this study further agrees with the studies of Sarpong, Sarpong and Lee (2021) in Ghana which revealed that haemoglobin and total protein levels of a child were the main causes of variation between the exact nutritional status of a child and that suggested by the MUAC value. That imbalance in the haemoglobin and protein levels affects the MUAC value (Sarpong et al., 2021). This study recorded significant strong correlations between serum zinc level with WHR ($r = 0.731$), Triceps skinfold ($r = -0.838$) and Subscapula skinfold ($r = -0.7.47$). This finding agrees with Fan et.al, (2017) who recorded inverse association between serum zinc level and obesity in their study of relationship between selected serum metabolic elements and obesity in children and Adolescents. Also Rios-Lugo et al (2020) reported decreased serum zinc levels in overweight and obese subjects at $p <0.05$with a negative correlation between BMI and serum

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zinc levels ($r = - 0.663$, $p < 0.0001$). These studies have revealed that serum zinc impact on body fat, of which WHR, triceps and subscapula skinfold thicknesses are indices of its measurement. According to Gunanti et al (2016), zinc may determine body adiposity through its role in energy metabolism, adipokine regulation and appetite control. Zinc is an important component of enzyme involved in energy metabolism. Lower zinc concentration is associated with abdominal fat as shown by the correlations that were observed in this study. Serum calcium had significant but negative correlation with WHR ($r = -0.421$, $p < 0.01$) in this study. Finding of this study is similar to that of Castro-Burbano et al (2016) who observed an inverse relationship between calcium intake and waist –hip- ratio in their subjects. In another study by Shahwan et al (2019) lower serum calcium level was significantly associated with abdominal obesity as measured by waist circumference (OR= 0.12, $p < 0.001$, Cl 95% 0,06 – 0,25). It is believed that obesity induces the production of inflammatory cytokines which stimulates bone absorption by osteoclasts that might subsequently lead to higher serum calcium levels in obese people, who already have elevated levels of triglyceride at the same time.

Conclusion

Thinness, underweight, obesity and moderate risk of cardiovascular diseases were observed among adolescent subjects in this study.Serum parameters assessed in this study showed that hypocalcaemia, zinc deficiency and mild anemia were present among the three age categories of adolescents in both locations of this study.An inverse relationship was observed between serum calcium and waist–hip-ratio of the adolescents. A significant positive correlation was observed between hemoglobin, body mass index and mid-upper arm circumference of the subjects in this study. Serum zinc also showed positive significant correlation with waist–hip-ratio, triceps and subscapula skinfolds. Lower zinc concentrations have been linked to abdominal fat.Nutrition education and counseling should be promoted in secondary schools to help reduce malnutrition.

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