Research Article ISSN 2834-7854

Journal of Nutrition Food Science and Technology

Household Food Security is Associated with Central Obesity but Not with Overweight and Obesity in Early Adolescence in the City of Colombo in Sri Lanka: A Cross Sectional Study

A.D.D.C. Athauda[1*], D.G.N.G. Wijesinghe[2] and G.A.P. Chandrasekara[3]

[1]*Postgraduate Institute of Agriculture, University of Peradeniya, Old Galaha Road, Peradeniya.*

[2]*Department of Food Science & Technology, University of Peradeniya, Old Galaha Road, Peradeniya.*

[3]*Department of Applied Nutrition, Faculty of Livestock, Fisheries & Nutrition, Makandura, Gonawila.*

***Corresponding authors**
A.D.D.C. Athauda,
Postgraduate Institute of Agriculture,
University of Peradeniya,
Old Galaha Road,
Peradeniya

Submitted : 9 Nov 2023 ; Published : 26 Feb 2024

Citation: Athauda, A. D. D. C. et al,(2024). Household Food Security is Associated with Central Obesity but Not with Overweight and Obesity in Early Adolescence in the City of Colombo in Sri Lanka: A Cross Sectional Study. J N food sci tech, 5(1):1-10.
DOI : https://doi.org/10.47485/2834-7854.1038

Abstract

Background: *The prevalence of overnutrition among early adolescents in the city of Colombo, the capital of Sri Lanka is rising steeply and the precise reason for the epidemic remains unclear. According to the insurance hypothesis, proximate driver of obesity could be food insecurity rather than food abundance per se.*

Aim: *This study was conducted to investigate the association between household food security status and overweight, obesity and central obesity in early adolescence in the city of Colombo.*

Methods: *A cross sectional study was conducted using 634 randomly selected adolescents aged 11-13 years in the city of Colombo, in which subjects were recruited using multistage stratified cluster sampling technique. Household food security score was assessed using USDA 18 Item Household Food Security/ Hunger Survey Module, while height, weight and waist circumference were measured. BMI-for-age Z score was calculated using WHO AnthroPlus software and waist: height ratio was calculated. Partial correlation between household food security score and BMI-for-age Z score and waist:height ratio were analyzed, after adjusting for daily energy intake, physical activity level, pubertal stage, birth weight and age.*

Results: *Household food security score was not associated with BMI-for-age Z score ($p>0.05$). Household food security score was inversely and weakly ($r=-0.373$) associated with waist:height ratio ($p = 0.002$) in girls but not in boys.*

Conclusion: *Overweight and obesity are not associated with food security status, however food secure girls tend to have more fat distribution in the abdominal area.*

Keywords : central obesity; early adolescents; household food security; obesity; overweight.

Introduction

The worldwide epidemic of overweight and obesity among children and adolescents is rising rapidly, with 340 million 5-19 year children and adolescents are either overweight or obese at present (World Health Organization[WHO], 2023). Despite increasing overweight and obesity, food insecurity is a leading public health problem in both developing and developed countries (Ali et al., 2013; Alisha et al., 2013).

In Sri Lanka, adolescents aged 11-13 years in the city of Colombo had the highest prevalence of overweight and obesity among adolescents, with an upward trend during the past decade with coexistence of high prevalence of undernutrition (Family Health Bureau [FHB], 2017; FHB, 2020). On the other hand, the food security status of Sri Lanka has not achieved better progress so far as Global Hunger Index ranked Sri Lanka as 64th out of 121 countries with a 13.6 score indicating a moderate level of hunger (Global Hunger Index [GHI], 2022). The city of Colombo holds nearly one fourth of Colombo District population, where the highest proportion (58.3 %) of the food-insecure population was reported in the country (Mayadunne & Romeshun, 2013).

The Insurance Hypothesis explains that the 'function of storing fat is to provide a buffer against shortfall in the food supply and thus, individuals should store more fat when they receive cues that access to food is uncertain. Applied to humans, this

implies that an important proximate driver of obesity should be food insecurity rather than food abundance *per se*' (Nettle, et al., 2017). Thus, the higher prevalence of overweight and obesity among 11-13 year adolescents in the city of Colombo could be related to household food insecurity.

Few studies have been conducted to find an association between food security status and overnutrition among adolescents, which have shown inconsistent results (Gundersen et al., 2009). Nevertheless, studies determining this association with central obesity among early adolescents are lacking. Moreover, most of these studies did not consider important covariates of the level of physical activity and daily energy intake of the subjects. Furthermore, in most studies, food insecurity was measured using subjects below the poverty line, and thus does not reflect the real population. However, most of these studies used 6 Item USDA Household Food Security/Hunger Survey Module, which does not contain questions to assess the food security status of children (Gary et al., 2000).

Thus, this cross-sectional study was designed to determine the relationship between food security status using the complete set of 18 Item Household Food Security/Hunger Survey Module, which is a stable and reliable measuring tool for food security rather than the prevalence of undernourishment (POU) (Food and Agriculture Organization [FAO] et al., 2019) and overweight, obesity, and central obesity among 11-13 year adolescents in the city of Colombo, Sri Lanka, after adjusting for confounding effects of daily energy intake, level of physical activity, pubertal stage, birth weight and age.

Materials and Methods

Experimental Design

A cross-sectional study was conducted to determine the association of household food security status with overweight, obesity, and central obesity among adolescents aged 11-13 years in the city of Colombo, Sri Lanka.

Setting

All adolescents aged 11-13 years, who were studying in schools located in the city of Colombo were included in this study. This study was conducted in 12 randomly selected schools located in the city of Colombo.

Sample Selection

The subjects were recruited from 11-13 year school children from 12 randomly selected schools located in the city of Colombo.

A sample of 634 participants was drawn from the study population using the multistage stratified cluster sampling technique. The stratification was based on "Administrative district" of Colombo city i.e. 1, 2A, 2B, 3, 4, 5; "Type of school" (national school and provincial school) and "School category" (Sinhala, Tamil, Sinhala & Tamil, and Muslim media).

In the first stage, all schools located in the city of Colombo were stratified into six strata by "Administrative district" of the city. The proportion of schools in each stratum was used to distribute 12 schools among the six strata. The numbers of subjects recruited from administrative district 1, 2A, 2 B, 3, 4, and 5 were 67, 114, 63, 233, 28, and 129, respectively.

The stratum "Type of school" (national school or provincial school) was used to recruit number of national and provincial schools for six strata based on the proportion of grade 7 (11-13 year) students in national and provincial schools in each administrative district. The number of subjects representing national schools was 327 and the number of provincial schools was 307.

At the third stage, "School category" stratum was used for the subject recruitment. The number of subjects from Sinhala medium, Tamil medium, Sinhala and Tamil media, and Muslim schools were 402, 51, 78, and 75, respectively. A proportionate sample representing all school categories was recruited and a cluster sample of subjects in a single classroom from each randomly selected school was drawn for the study.

Adolescents who were not healthy, living outside the Colombo city area, or living away from their parents were excluded from this study. The dropout rate of the study was 4.4%, and 606 subjects were participated in this study.

Variables

The variables of household food security score with BMI-for-age Z-score and waist-to-height ratio were used to investigate the relationship between household food security status and overweight, obesity, and central obesity. Potential confounders of the association were daily energy intake, level of physical activity, pubertal stage, birth weight, and age.

Data Measurement

Household Food Security Status

The pre-tested and translated (Sinhala & Tamil) form of USDA 18 Item Household Food Security / Hunger Survey Module questionnaire (Gary et al., 2000) was administered to the mother or guardian of the subject to measure past 12 month household food security status of the subjects.

The questionnaire consisted of 18 questions which assessed "worried food would run out", "food bought just didn't last", couldn't afford to eat balanced meals", "relied on few kinds of low-cost food for children", "couldn't feed the children a balanced meal", "children were not eating enough", "adult cut size of meals or skipped meals", "adult cut size of meals or skipped meals in 3 or more months", "adult ate less than felt they should", "adult hungry but didn't eat", "respondent lost weight", "adult didn't eat for whole day", "adult didn't eat for whole day in 3 or more months", "cut size of children's meals", "children skipped meals", "children skipped meals in 3 or more months", "children were hungry" and "children didn't eat for whole day" (Gary et al., 2000).

Nutritional Status of the Adolescents

Standing height, weight, and waist circumference

measurements were taken by a single assessor throughout the study, following standard procedures (Lee & Nieman, 1996). The standing height of each subject was measured using a Seca portable stadiometer 217 (SECA, Hamburg, Germany) to the nearest 0.1 cm accuracy, and the weight was measured using a Seca 874 electronic weighing scale (SECA, Hamburg, Germany) to the nearest 0.01 kg of accuracy. The height of the subjects was measured, while, standing in erect posture and with head in a "Frankfort plane"; heels together, arms hanging in natural manner, legs straight and shoulders relaxed, as well as, heals, buttocks, shoulder blades and back of the head of the subject were against the vertical surface of the stadiometer (Lee & Nieman, 1996). The weight of the subject was measured in minimal light clothing prior to the meal, when the subject was in an erect posture, looking straight ahead, arms at sides hanging in a natural manner, body weight was equally distributed on both feet, and the subject was relaxed (Lee & Nieman, 1996). The second and third readings were obtained for both height and weight to verify the measurements.

Waist circumference was measured to the nearest 0.1 cm accuracy using a Seca 201 circumference tape (SECA, Hamburg, Germany). Waist circumference was measured at the least circumference of the abdominal area between the lowest rib and the umbilicus of the subject, when the subject was standing in erect posture, abdominal muscle relaxed, arms at sides hanging in a natural manner, feet together, and wearing minimal clothing (Lee & Nieman, 1996). The measurement was taken before having food or drink, and the second and third readings were taken to verify the accuracy of the first reading.

Confounders

Daily Energy Consumption

A pre tested three- day diet diary (Sinhala & Tamil) was used to assess the daily energy intake of the subjects on three consecutive days, including two weekdays and one weekend day, after a comprehensive explanation of keeping records on the diet diary and recording portion sizes of foods and beverages using household standard food models. The time, place, type, and amount of all the foods and beverages consumed in household measurements and the preparation method of each food item were recorded by the subjects with the assistance of the mother.

Level of Physical Activity

The level of physical activity of the subjects during the past seven days was assessed using the pre-tested, translated form (Sinhala and Tamil) of the physical activity questionnaire for older children PAQ – C (Kowalski et al., 2004). The questionnaire consisted of 10 questions regarding physical activity in spare time, which included, how often physically active during physical education classes, what was done most of the time at recess, what was done normally at lunch, how many days sports were done right after school, how many evenings sports were done, how many times sports were done on the last weekend, which one describes best for the last 7 days, mark how often physical activities were done in the last 7 days, and were sick or did anything that prevented doing normal physical activities in the last week (Kowalski et al., 2004).

Socio-demographic Data

A pre-tested general questionnaire (Sinhala & Tamil) was used to collect socio-demographic information on ethnicity, gender, date of birth, birth weight, household size, level of education and occupation of parents, household monthly income, and living area of the household. The household monthly income was categorized in to 5 levels as "below USD 140"; "between USD 140 - 280"; "between USD 281 - 420"; "between USD 421 - 560" and "above USD 560". The level of education of parents was categorized into 6 levels as " No schooling"; "Grade 1-5"; "Grade 6-10"; Ordinary Level (O/L)"; "Advanced Level (A/L)" and "Diploma/Degree".

Sexual Matuarity Stage

Tanner staging was performed to determine the sexual maturity stage of the subjects (Brown, 2002).

Birth Weight

The birth weights of the subjects were extracted from the Child Health Development Record (CHDR) developed for the Sri Lankan chidren (FHB, 2014).

Elimination of Bias

Data collection was performed by the principal researcher with the assistance of a trained research assistant throughout the study. Both researchers were blinded to the current nutritional status and other information on daily energy intake, physical activity, household food security status, and socio-demographic characteristics of the participants. The same researcher collected a single type of data throughout the study period.

Data Analysis

Household Fod Security Status

According to the USDA Household Food Security/ Hunger Survey Module, affirmative responses were assigned as "1" and negative responses were assigned as "0". The sum of all affirmative responses was used to determine the household food security status and household food security score of the subjects. Household food security status was categorized into four levels based on affirmative responses as follows:0-2 - "food secure"; 3-7 - "food insecure without hunger"; 8-12 - "food insecure with moderate hunger" and 13-18 - "food insecure with severe hunger" (Gary et al., 2000).

Nutritional Status

The mean values of all anthropometric measures of each subject were used for the calculation of nutritional indices to determine the current nutritional status of the subjects. Body Mass Index (BMI) was calculated using the current standing height and body weight of the subjects [BMI = Weight (kg)/ Height^2 (m^2)]. Height-for-age and BMI– for–age of the subjects were determined using age- and sex-specific WHO growth charts developed for children aged 5-19 years in Sri

Lanka (FHB, 2014) and WHO cut-off values were used to determine the nutritional status of the subjects. Height–for–age ≤ -2 SD as "stunted"; Height–for–age > -2 SD as "normal height"; BMI– for– age ≤ -2 SD as "wasting"; BMI–for–age between -2 SD to +1 SD as "normal weight"; BMI–for–age between +1 SD to +2 SD as "overweight" and BMI –for–age > + 2 SD as "obese" (WHO, 2023). Furthermore, the BMI-for-age Z score was calculated using WHO AnthroPlus version 1.0.4. Software (WHO, 2009), in order to find the association between household food security status and BMI-for-age Z score.

Waist-to-height ratio [waist (cm) / height (cm)] was calculated by dividing waist circumference by standing height of the subject. If the waist-to-height ratio was ≥ 0.5, subjects were classified as "abdominal obesity present" and if, waist-to-height ratio was < 0.5, subjects were classified as "abdominal obesity absent" (Lee et al., 2008).

Socio-demographic Data

All categorical variables, including socio-demographic characteristics of the subjects (ethnicity, household monthly income, parental level of education and occupation, household size, and household living area) were converted into percentage values, and differences were presented by gender of the subjects.

The household size was categorized in to three levels as "below 5", "between 5-8" and "above 8"; household living area was categorized in to three levels as "below 126.46 m^2", "between 126.46 -252.90 m^2 " and "above 252.90 m^2". In addition, parental occupation was categorized in to six as "No", "Labourer", "Self-employed", "Non-Executive", "Executive" and "Abroad". The birth weight of the subjects was categorized into three levels as "below 2500 g", "between 2500g – 3500g" and "above 3500g" and presented in percentage values by gender.

Daily Energy Consumption

The recorded amounts of foods and beverages consumed by each subject in household measurements were converted in to "grams" and "milliliters" by using the G-conversion table developed for Sri Lankan foods and beverages prior to analyze three-day diet diaries using Food Base 2000 software developed for analyzing food composition of Sri Lankan foods, mix dishes and beverages. The Food Base 2000 software analyzes foods, mixed dishes, and beverages for energy, protein, carbohydrate, fat, vitamins, minerals, fiber, starch, total sugar, added sugar, cholesterol, alcohol, % energy from fat, % energy from carbohydrate, % energy from protein, % energy from saturated fat, and % energy from added sugar. The mean value of the energy intake of each participant was calculated and used as a covariate.

Level of Physical Activity

The level of physical activity of subjects was classified using a five-scale physical activity level, based on the final score obtained for the PAQ-C questionnaire by each subject (Kowalski et al., 2004) and the mean physical activity score of subjects was calculated by gender.

Sexual Maturity Stage

Tanner staging (Brown, 2002) was performed to assess the sexual maturity stage of the subjects. Pubertal stage of the subjects was determined using the cut-offs recommended by the World Health Organization (1995), where the breast stage 2 for girls and genitalia stage 3 for boys. These cut-offs were used to classify the subjects in to "pubertal" and "pre-pubertal" groups.

Statistical Analysis

The summarized categorical data (ethnicity, household size, household monthly income, household living area, level of education and occupation of parents, birth weight, and pubertal stage) were analyzed for gender differences using the chi-squared test (Gupta, 2004) at a significance level of 0.05. Moreover, gender differences in nutritional status and household food security status were analyzed using the chi-squared test at a significance level of 0.05 (Gupta, 2004). Further, gender difference of mean daily energy intake and mean physical activity score were analyzed using 2-independent sample t- test at a significance level of 0.05.

Partial correlation models were developed to evaluate the association of household food security score with BMI-for-age Z-score and waist-to-height ratio after controlling for potential confounding factors of physical activity level, daily energy consumption, pubertal stage, birth weight, and age of the subjects. Model 1 was not adjusted for the confounding factors. Model 2 was adjusted for daily energy consumption. Model 3 was adjusted for daily energy consumption and physical activity level. Model 4 was adjusted for daily energy consumption, physical activity level, and pubertal stage. Model 5 was adjusted for daily energy consumption, physical activity level, pubertal stage, and birth weight. Model 6 was adjusted for daily energy consumption, physical activity level, pubertal stage, birth weight, and age.

All statistical analyses were performed using the Statistical Package for the Social Sciences software version 21 (SPSS Inc., Chicago, IL, USA).

Results

Socio-demographic characteristics of the subjects

The study cohort consisted of 336 boys (55.4%) and 270 girls (44.6%) and mean (± SD) age of boys and girls were 12.14 (± 0.36) years and 12.13 (± 0.36) years respectively. The socio-demographic characteristics, birth weight, and pubertal stage of the participants are shown in Table 1.

Table 1: Socio – demographic characteristics, birth weight and pubertal stage of the subjects

Characteristic of the subject	Boys		Girls	
	[n]	%	[n]	%
Ethnicity[a]	(n= 513)			
Sinhalese	182	71.65	102	39.38
Tamil	53	20.87	24	9.27
Muslim	18	7.09	131	50.58
Family size[a]	(n=384)			
Below 5	90	45.45	52	27.96
Between 5 - 8	103	52.02	112	60.22
Above 8	5	2.52	22	11.83
Household monthly income[a]	(n=387)			
Below USD 140	39	19.21	62	33.70
Between USD 140 – 280	54	26.60	71	38.59
Between USD 281 – 420	42	20.69	25	13.59
Between USD 421 – 560	31	15.27	19	10.33
Above USD 560	37	18.23	7	3.80
Household living area[a]	(n=281)			
Below 126.46 m^2	57	39.04	85	62.96
Between 126.46 m^2 - 252.90 m^2	41	28.08	32	23.70
Above 252.90 m^2	48	32.88	18	13.33
Birth weight[b]	(n=307)			
Below 2500 g	12	7.50	20	13.61
Between 2500 – 3500 g	129	80.62	113	76.87
Above 3500 g	19	11.88	14	9.52
Pubertal stage[b]	(n=524)			
Pre-puberty	164	55.4	143	62.7
Puberty	132	44.6	85	37.3
Maternal occupation[b]	(n=390)			
No	124	61.39	172	78.90
Labourer	2	0.99	7	3.21
Self-employment	7	3.46	11	5.04
Non- Executive	46	22.77	20	9.17
Executive	21	10.40	5	2.29
Abroad	2	0.99	3	1.38
Maternal level of education[a]	(n=388)			
No schooling	4	1.98	3	1.61
Grade 1 - 5	5	2.48	18	9.68
Grade 6 – 10	23	11.39	57	30.64
Ordinary Level (O/L)	36	17.82	51	27.42
Advanced Level (A/L)	75	37.13	37	19.89
Diploma / Degree	59	29.21	20	10.75

Paternal occupation[a]	(n=361)			
No	6	3.16	9	5.26
Labourer	20	10.53	35	20.47
Self-employment	69	36.32	71	41.52
Non- Executive	30	15.79	31	18.13
Executive	62	32.63	21	12.28
Abroad	3	1.58	4	2.34
Paternal level of education[a]	(n=364)			
No schooling	5	2.59	7	4.09
Grade 1 – 5	6	3.11	9	5.26
Grade 6 – 10	22	11.40	47	27.48
Ordinary Level (O/L)	38	19.69	53	30.99
Advanced Level (A/L)	60	31.09	37	21.64
Diploma / Degree	62	32.12	18	10.53

[a]Significantly different by chi-squared test ($p< 0.001$)
[b]No significant difference by chi – squared test ($p> 0.05$)

Anthropometric Characteristics of the Subjects

Mean (±SD) height, weight and waist circumference of the subjects were 147.3 (± 7.5) cm, 40.12 (± 11.65) kg and 66.5 (±10.4) cm respectively. Their mean (± SD) Body Mass Index (BMI) was 18.34 (± 4.22) kgm^{-2} and gender differences in anthropometric characteristics of the subjects are summarized in Table 2.

Table 2: Anthropometric characteristics of the subjects

Characteristics	Boys			Girls		
	[n]	Mean	SD	[n]	Mean	SD
Height (cm)[a]	296	147.10	7.60	212	147.50	7.30
Weight (kg)[a]	296	40.35	11.74	229	39.96	11.55
Waist circumference (cm)[b]	296	67.20	10.90	200	65.30	9.50
Body Mass Index (kgm^{-2})[a]	296	18.44	4.29	206	18.21	4.13

[a]No significant difference by independent sample t test ($p> 0.05$)
[b]Significantly different by independent sample t test ($p< 0.05$)

Nutritional status of the Subjects

The majority of the subjects had normal height (94.8 %) and weight (55.7 %). The prevalence of undernutrition, as indicated by stunting, was 5.2 %, and wasting was 15.8 %. The prevalence of overweight, obesity, and central obesity were 17.7%, 10.8%, and 40.9 %, respectively. There was no significant gender difference in the nutritional status of the study cohort, as shown in Figure 1 ($p>0.05$).

Prevalence (%)

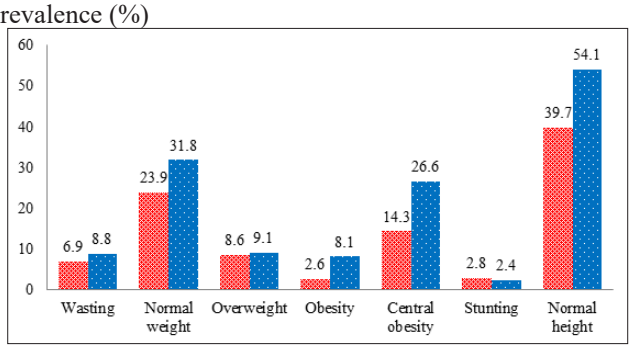

Figure 1: Nutritional status of 11-13 year adolescents in the city of Colombo[a] Boys Girls [a]No significant difference by chi – squared test (p> 0.05)

Household Food Security Status

The mean (± SD) score for the 18 Item Household Food Security/Hunger Survey Module was 2.95 (± 3.72), indicating that the subjects were food insecure without hunger. The prevalence of household food security and food insecurity were 60.9 % and 39.2 %, respectively. Majority of the food insecure adolescents were food insecure without hunger (26.8%) while, 9.7 % were food insecure with moderate hunger, and 2.7 % were food insecure with severe hunger. There were no significant gender differences in household food security status among the subjects, as shown in Figure 2 (p > 0.05).

Prevalence (%)

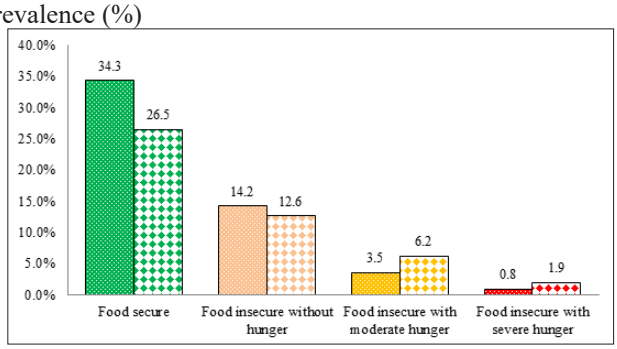

Figure 2: Prevalence of household food security status among 11-13 year adolescents in the city of Colombo[a] Boys Girls [a]No significant difference by chi – squared test (p> 0.05)

Level of Physical Activity

The mean (± SD) physical activity score of the subjects was 2.49 (± 0.63) out of 5, and boys were more physically active [mean physical activity score = 2.68 (±0.59)] than girls [mean physical activity score = 2.26 (±0.61)]. The level of physical activity differed significantly by gender (p < 0.001).

Daily Energy Intake

The mean (± SD) daily energy consumption of the subjects was 69.78 (±2.00) MJ per day. The mean (± SD) daily energy consumption of boys and girls were 7.11 (± 1.78) MJ and 6.88 (± 2.31) MJ respectively and there was no significant gender difference observed in daily energy consumption (p>0.05).

Association between household food security score and BMI-for-age Z score

Boys showed a weak inverse relationship (r= -0.193) between household food security score and BMI-for-age Z-score (p= 0.007). However, this association became insignificant (p>0.05) after controlling for daily energy consumption, physical activity level, pubertal stage, birth weight and age.

There was no significant association between the household food security score and BMI-for-age Z score in girls, even after adjusting for confounders of daily energy consumption, level of physical activity, pubertal stage, birth weight and age (p>0.05) (Table 3).

Association between household food security score and waist: height ratio

The association between the household food security score and waist-to-height ratio in boys was weak and negative (r = -0.152; p= 0.033), while it was not significant in girls (p>0.05). However, this association in boys disappeared (p>0.05); in contrast, a weak negative association (r= -0.373; p=0.002) was observed in girls, when controlling for confounding effects of daily energy consumption, level of physical activity, pubertal stage, birth weight, and age (Table 4).

Table 3: Association between household food security score and BMI-for-age Z score

	BMI-for-age Z score					
	Boys			Girls		
	n	p	r	n	p	r
Household food security score						
Model 1	[262]	0.007	-0.193	[147]	0.944	-0.006
Model 2	[122]	0.005	-0.250	[83]	0.928	0.010
Model 3	[120]	0.004	-0.261	[81]	0.900	0.014
Model 4	[118]	0.008	-0.242	[80]	0.230	-0.134
Model 5	[92]	0.061	-0.194	[65]	0.287	-0.132
Model 6	[90]	0.066	-0.193	[64]	0.194	-0.162

r – Pearson correlation coefficient
Model 1 was not adjusted for any of the confounding factors
Model 2 was adjusted for daily energy consumption
Model 3 was adjusted for daily energy consumption and level of physical activity
Model 4 was adjusted for daily energy consumption, physical activity level, and pubertal stage
Model 5 was adjusted for daily energy consumption, physical activity level, pubertal stage and birth weight
Model 6 was adjusted for daily energy consumption, physical activity level, pubertal stage, birth weight, and age

Table 4: Association between household food security score and waist: height ratio

	waist: height ratio					
	Boys			Girls		
	n	p	r	n	p	r
Household food security score						
Model 1	[198]	0.033	-0.152	[141]	0.235	-0.101
Model 2	[124]	0.135	-0.134	[81]	0.406	-0.092
Model 3	[122]	0.111	-0.144	[79]	0.480	-0.080
Model 4	[120]	0.109	-0.146	[78]	0.034	-0.238
Model 5	[92]	0.275	-0.114	[63]	0.006	-0.338
Model 6	[89]	0.345	-0.100	[62]	0.002	-0.373

r – Pearson correlation coefficient
Model 1 was not adjusted for any of the confounding factors
Model 2 was adjusted for daily energy consumption
Model 3 was adjusted for daily energy consumption and level of physical activity
Model 4 was adjusted for daily energy consumption, physical activity level, and pubertal stage
Model 5 was adjusted for daily energy consumption, physical activity level, pubertal stage and birth weight
Model 6 was adjusted for daily energy consumption, physical activity level, pubertal stage, birth weight, and age

Discussion

According to our study, prevalence of overweight (17.7%) and obesity (10.8%) in this study was above the national value of 11-13 year school children (overweight – 6.8% and obesity – 2.9%) (FHB, 2020) and prevalence of household food insecurity was higher (39.2%) than the national (18.9%) and Colombo District (38%) figures (Mayadunne & Romeshun, 2013). The higher prevalence of overnutrition and food insecurity in the city of Colombo compared to national figures could be due to difference in time, sampling frames and measuring tools.

Association of food security status with overweight and obesity

Previous studies on household food security and nutritional status are limited, and the findings are inconsistent. The findings of this study suggest that neither household food security nor food insecurity is associated with overweight and obesity in both boys and girls, even though the measuring tools used in the current study are different from those used in previous studies with similar findings. Although several studies have found an inverse association between food security and overweight and obesity in children and adolescents, the association was not adjusted for important confounders of physical activity and energy intake (Biadgilign et al., 2021; Casey et al., 2001; Katsaras et al., 2009).

Laraia et al. (2004) found no association between food security status and overweight and obesity in children and adolescents aged less than 18 years after controlling for socio-economic factors, whose food insecurity was measured using the Behavioural Risk Factor Surveillance System (BRFSS) and overnutrition was measured using BMI. Furthermore, a study

conducted using 0 -17 year children and adolescents found no significant difference in overweight among food insufficient vs. food-sufficient groups when food insecurity was assessed using the Continuing Survey of Food Intakes in Individuals (CSFII) method, and overweight was determined as > 85th percentile of BMI-for-age (Casey et al., 2001). Moreover, Gubert et al. (2016) couldn't find an association between household food insecurity and overweight in children, where food insecurity was measured using the Brazilian Food Insecurity Measurement Scale (EBIA), and overweight was determined by weight-for-height Z score. In addition, the likelihood of being overweight or at risk of being overweight was not significantly different between food secure and food insecure low-income adolescents 10-15 years in the USA, whose food security status was measured using the 18-item USDA Household Food Security/Hunger Survey Module (Gundersen et al., 2008). Basirat et al. (2012) could not find any relationship between food insecurity and obesity in 6 - 12 year Iranian children and adolescents using the Radimer – Cornell questionnaire. Furthermore, household food security status was not associated with overweight or obesity among adolescents in urban setting in Ethiopia (Biadgilign et al., 2021).

Association of food security status and central obesity

According to our study, the mean waist circumference of boys was higher than that of girls, which could be due to the deposition of more visceral fat in boys than in girls (Wajchenberg, 2000). However, our study showed a positive association between household food security and central obesity in girls but not in boys. Previous studies assessing the association between household food security status and central obesity are lacking. A cross-sectional study of 6-11 year students in Iran did not find any association between food insecurity assessed using the Radimer/Cornell questionnaire and central adiposity (Basirat et al., 2012).

Since the majority of girls were living in larger households with lower household monthly income and lower levels of parental education, food-secured girls could be fed cheaper energy-dense foods, which are highly available in the city of Colombo, leading to central adiposity in girls.

Limitations

However, our study had several potential limitations. Overweight and obesity were determined using the Z-scores of BMI-for-age, which is an anthropometric indicator. Assessing overweight and obesity using direct measurement of body fat and abdominal fat distribution is more accurate than anthropometric indices.

In conclusion, household food insecurity or security is not associated with overweight or obesity in 11-13 year adolescents. However, food-secure early adolescent girls, but not boys, tend to have more fat distribution in the abdominal area.

Acknowledgements

I acknowledge Prof. K.D.R.R. Silva, Senior Lecturer, Department of Applied Nutrition, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka for the provision of access to FoodBase 2000 software and Dr. C. Wickramarachchi, Head, Department of Statistics, University of Sri Jayawardanapura for instructing for statistical analysis.

Financial Support

This work was supported by the Research Facilitation Fund (Grant No: RFF/16071) of Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka.

Conflict of Interest

None – A.D.D.C. Athauda
None – D.G.N.G. Wijesinghe
None – G.A.P. Chandrasekara

Authorship

The corresponding author, A.D.D.C. Athauda was the principal investigator involved in conceptualization, data curation, formal analysis, investigation, designing the methodology, project administration, visualization and writing the journal manuscript. The co-authors, D.G.N.G. Wijesinghe and G.A.P. Chandrasekara finalized the content of the journal manuscript.

Ethical Standards Disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethical Review Committee of National Institute of Health Sciences (Ref: NIHS/ERC/18/78R). In addition, a written informed consent was obtained from all the participants.

References

1. World Health Organization (2009) WHO AnthroPlus for Personal Computers Manual: Software for Accessing Growth of World's Children's and Adolescents. WHO. https://cdn.who.int/media/docs/default-source/child-growth/growth-reference-5-19-years/who-anthroplus-manual.pdf
2. Ali, D., Saha, K. K., Nguyen, P. H., Diressie, M. T., Ruel, M. T., Menon, P., & Rawat, R. (2013). Household food insecurity is associated with higher child undernutrition in Bangladesh, Ethiopia, and Vietnam, but the effect is not mediated by child dietary diversity. *Journal of Nutrition 143*(12), 2015–21.
   DOI: https://doi.org/10.3945/jn.113.175182
3. Alisha, C.J., Nord, M. & Singh, A. (2013). Household food security in the United States in 2012. Washington, DC: USDA Economic Research Service. 1-25 https://www.ers.usda.gov/webdocs/publications/45129/39937_err-155.pdf
4. Family Health Bureau (2017). School Health Performance Annual Report 2017. (pp.33-7). Mnistry of Health.
5. Family Health Bureau (2020). School Health Performance Annual Report 2018. (p.60). Mnistry of Health.
6. Global Hunger Index (2022). (2023, June 18). Sri Lanka

https://www.globalhungerindex.org/sri-lanka.html
7. Mayadunne, G. & Romeshun, K. (2013). Estimation of prevalence of food insecurity in Sri Lanka. Sri Lankan *Journal of Applied Statistics, 14*(1), 27- 40. DOI: https://doi.org/10.4038/sljastats.v14i1.5875
8. Nettle, D., Andrews, C., & Bateson, M. (2017). Food insecurity as a driver of obesity in humans: the insurance hypothesis. *Behaviour Brain Science*, 40, 105. DOI: https://doi.org/10.1017/s0140525x16000947
9. Gundersen, C., Lohman, B., Eisenmann, J., Garasky, S., & Stewart, S. (2008). Lack of association between child-specific food insecurity and overweight in a sample of 10–15 year old low-income youth. *Journal of Nutrition, 138*(2), 371–8. DOI: https://doi.org/10.1093/jn/138.2.371
10. Gary, B., Nord, M., Price, C., Hamilton, W. & Cook, J. (2000). Guide to Measuring Household Food Security, Revised 2000. (pp. 5-26,52-7).U.S. Department of Agriculture Food and Nutrition Service. https://naldc.nal.usda.gov/download/38369/PDF
11. Food and Agriculture Organization, International Fund for Agricultural Development, United Nations Children's Fund, World Food Programme, & World Health Organization (2019). The State of Food Security and Nutrition in the World 2019. (pp. ii,2-4,80). Food and Agriculture Organization.
12. Lee, R. D., & Nieman, D. C. (1996). Nutritional Assessment. Anthropometry. (pp.188-95). McGraw-Hill Companies.
13. Kowalski, K. C., Crocker, P.R. & Donen, R.M. (2004). The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) Manual. (pp. 8-11). University of Saskatchewan. https://www.prismsports.org/UserFiles/file/PAQ_manual_ScoringandPDF.pdf
14. Brown, J. E. (2002). Nutrition through the Life Cycle. Nutrition during adolescence. (pp. 241-69). Wadsworth / Thomson Learning.
15. Family Health Bureau (2014). Assessment of Nutiritional Status of School Children Refernce Growth Chart. (pp.8-12). Ministry of Health.
16. World Health Organization (2023). Fact Sheet. Overweight and obesity. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
17. Lee, C. M., Huxley, R. R., Wildman, R. P., & Woodward, M. (2008). Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. *Journal of Clinical Epidemiology, 61*(7), 646–53. DOI: https://doi.org/10.1016/j.jclinepi.2007.08.012
18. Gupta, S.C. (2004). Fundamentals of Statistics. Correlation, Sampling Theory & Design Sample Surveys, Chi-Square Test. (pp.8.38 - 8.45, 15.21 - 15.28, 18.1 - 18.37). Himalaya Publishing House.
19. Biadgilign, S., Gebremariam, M. K., & Mgutshini, T. (2021). The association of household and child food insecurity with overweight/obesity in children and adolescents in an urban setting of Ethiopia. BMC Public Health, 21(1), 1336. DOI: https://doi.org/10.1186/s12889-021-11392-6
20. Casey, P. H., Szeto, K., Lensing, S., Bogle, M., & Weber, J. (2001). Children in food-insufficient, low-income families: prevalence, health and nutrition status. *Archives of Pediatrics and Adolescent Medicine. 155*(4), 508–14. DOI: https://doi.org/10.1001/archpedi.155.4.508
21. Katsaras, M., Sherry, B. & Kallio, J. (2009). Food insecurity is associated with overweight in children younger than 5 years of age. *Journal of American Diet Association, 109*(10), 1790-4. https://www.sciencedirect.com/science/article/abs/pii/S0002822309012668
22. Laraia, B. A., Siega-Riz, A. M., & Evenson, K. R. (2004). Self-reported overweight and obesity are not associated with concern about enough food among adults in New York and Louisiana. *Preventive Medicine, 38*(2), 175-81. DOI: https://doi.org/10.1016/j.ypmed.2003.09.033
23. Gubert, M. B., Spaniol, A. M., & Bortolini, G. A. (2016). Household food insecurity, nutritional status and morbidity in Brazilian children. *Public Health Nutrition, 19*(12), 2240–5. DOI: https://doi.org/10.1017/s1368980016000239
24. Gundersen, C., Garasky, S., & Lohman, B. J. (2009). Food insecurity is not associated with childhood obesity as assessed using multiple measures of obesity. *Journal of Nutrition, 139*(6), 1173–8. DOI: https://doi.org/10.3945/jn.109.105361
25. Basirat, R., Abargouei, A. S., & Esmailzadeh, A. (2012). The association between household food insecurity and childhood obesity among Iranian school-aged children in Farokhshahr. Koomesh, 13(2), 254-63. Retrieved from https://koomeshjournal.semums.ac.ir/browse.php?a_id=1255&sid=1&slc_lang=en
26. Wajchenberg, B. L. (2000). Subcutaneous and visceral adipose tissue: their relation to the metabolic syndrome. Endocrine Reviews, 21(6), 697–738. DOI: https://doi.org/10.1210/edrv.21.6.0415