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Socio-demographic and lifestyle predictors of high adiposity among primary school children aged 8-9 years in the Colombo Municipal area

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Abstract

Background

Socio-demographic and lifestyle factors have an impact on the prevalence of obesity. Therefore, the present study aimed to identify the socio-demographic and lifestyle predictors associated with high body fat in 8 to 9-year-old primary school children.

Methods

Data used in the present analysis were derived from a case-control study, where cases (percentage body fat- males >28.6% and females >33.7%, N=160; males=81) and controls (percentage body fat- males ≤ 28.6% and females ≤33.7%, N=164; males=80) were recruited from primary schools in the Colombo Municipal area. Anthropometry and body composition were measured, and socio-demographic, dietary and physical activity data were collected. A multivariate logistic regression analysis was performed and adjusted odd ratios (AOR) with 95% confidence intervals (CIs) were calculated.

Results

High body fat was associated with high birth weight (females-AOR 10.57 95%CI 1.65-67.84), high household income (males-AOR 3.20 95%CI 1.25-8.20), unhealthy snacking (>2/day) (females-AOR 3.16 95%CI 1.12-8.90), unhealthy snacking in the school environment (males-AOR 3.20 95%CI 1.28-8.00), high consumption of sweetened carbonated beverages (females-AOR 6.57 95%CI 1.88-22.92), low levels of vigorous intensity activities (<3 times/week) (males-AOR 3.48 95%CI 1.32-9.21, females-AOR 2.92 95%CI 1.13-7.52), screen time (>2hours/day) (males-AOR 8.97 95%CI 2.59-31.09, females-AOR 11.22 95%CI 4.24-29.64) and non-screen activities (>2hous/day) (females-AOR 3.81 95%CI 1.35-10.77).

Conclusion

Birth weight, household income, unhealthy snacking, consumption of sweetened carbonated beverage, physical inactivity and sedentary behaviours were the major predictors of high body fat in this study population.

Background

Excess weight gain during childhood remains a serious public health concern in both developed and developing countries worldwide [1]. An increase in the prevalence of overweight has been observed among adolescents in the South Asian region, including Sri Lanka [2]. Furthermore, obese children are more likely to have other cardiovascular risk parameters than normal weight children, which may persist into adulthood [3].

Nutrition transition, characterized by shifts in dietary and physical activity patterns, has a significant impact on the prevalence of obesity and non-communicable diseases. Low and middle-income countries are experiencing a rapid nutrition transition, with the South Asian region including Sri Lanka, also witnessing the same during the last few decades [4-6].

Family dynamics which surround a child's domestic life plays an important role in establishing eating behaviours that will persist into their adult life [7]. An obesogenic environment at the societal level makes a child move away from family meals towards calorie-dense unhealthy food choices. Higher calorie consumption due to unhealthy eating patterns and low energy expenditure due to physical inactivity leads to an energy imbalance resulting in obesity. Easy access to electronic devices, such as computers, televisions and communication devices, has increased sedentary behaviours among children [8].

Socio-economic status also has a substantial impact on the development of overweight and obesity in children. Several studies, both regional and worldwide, have reported an association between socio-economic status and obesity among children [9,10], resulting from food choices and dietary habits [11].

Obesity is multifactorial in origin [12], and identifying the factors that could be easily modified are essential for targeted preventive actions, which are necessarily population specific. In addition, sex-based differences have been observed in the prevalence of obesity [13], fat distribution [14,15] and the influence of the obesogenic environment on the child [16]. Since childhood patterns are established earlier than adolescents, studying these patterns of pre-pubertal children is of importance and are likely to differ from patterns among older children. Lifestyle factors, including diet and physical activity along with socio-demographic and economic characteristics which vary across geographical regions need better understanding, since current interventions targeting childhood obesity seems to have had minimal impact [17]. Therefore, the present study aimed to identify the socio-demographic and lifestyle factors associated with high body fat among 8-9 year old primary school children from an urban area of Sri Lanka.

Methods

Data used in the present study were collected between August 2015 to November 2016 during a case-control study carried out among primary school children aged 8-9 years in the Colombo Municipal area to analyse the association between adiposity and micronutrient status. Therefore, the sample size was determined based upon previous data on micronutrient deficiencies [18-22] among the obese and normal weight children. Thus, the highest sample size estimated per group was 81 (with α error of 0.05 and 80% statistical power) considering a 10% dropout rate. Four groups were formed with the stratification by gender in both cases and controls. The present analysis included cases (N=160; males=81) defined as those having a higher body fat percentage (males >28.6% and female >33.7%) level and controls (N=164; males=80) defined as those with normal body fat percentage (males ≤28.6% and females ≤33.7%) Figure 1 [15].

Inclusion and exclusion criteria

Eight to nine-year-old children who were residents of the Colombo Municipal Council area and identified to have normal and high body fat percentage defined according to cut-off values [15] were selected. Children with any chronic illness/congenital disability, on micronutrient supplementation, on a restricted diet and those who had any infection within the preceding two weeks of the study were excluded.

This study was carried out with approvals from Ethics Review Committees of the Faculty of Medicine, University of Colombo (EC-14-168), and the Lady Ridgeway Children's Hospital, Sri Lanka. Approval was also obtained from the Ministry of Education, Sri Lanka and the principals of schools in which the study was conducted. Informed parental written consent and assent from the children were obtained for the enrollment of participants after detailing the study.

Anthropometric and body fat measurements

Height was measured to the nearest 0.1cm without shoes using a portable stadiometer (SECA 225; Germany), and weight was measured using an electronic weighing scale (SECA 803; Germany) to the nearest 0.1kg with light clothes. Body Mass Index (BMI) was calculated as weight (in kilograms) divided by height squared (in meters). Body fat was measured by the bioelectrical impedance analysis (BIA) technique using an InBody 230® multi-frequency analyzer (Biospace Co., Ltd., Seoul, Korea) where the subject stands on the BIA machine placing both feet on the electrodes and holding the hand-held electrodes kept further away from the body, wearing minimal clothes and without any metallic wear/jewellery.

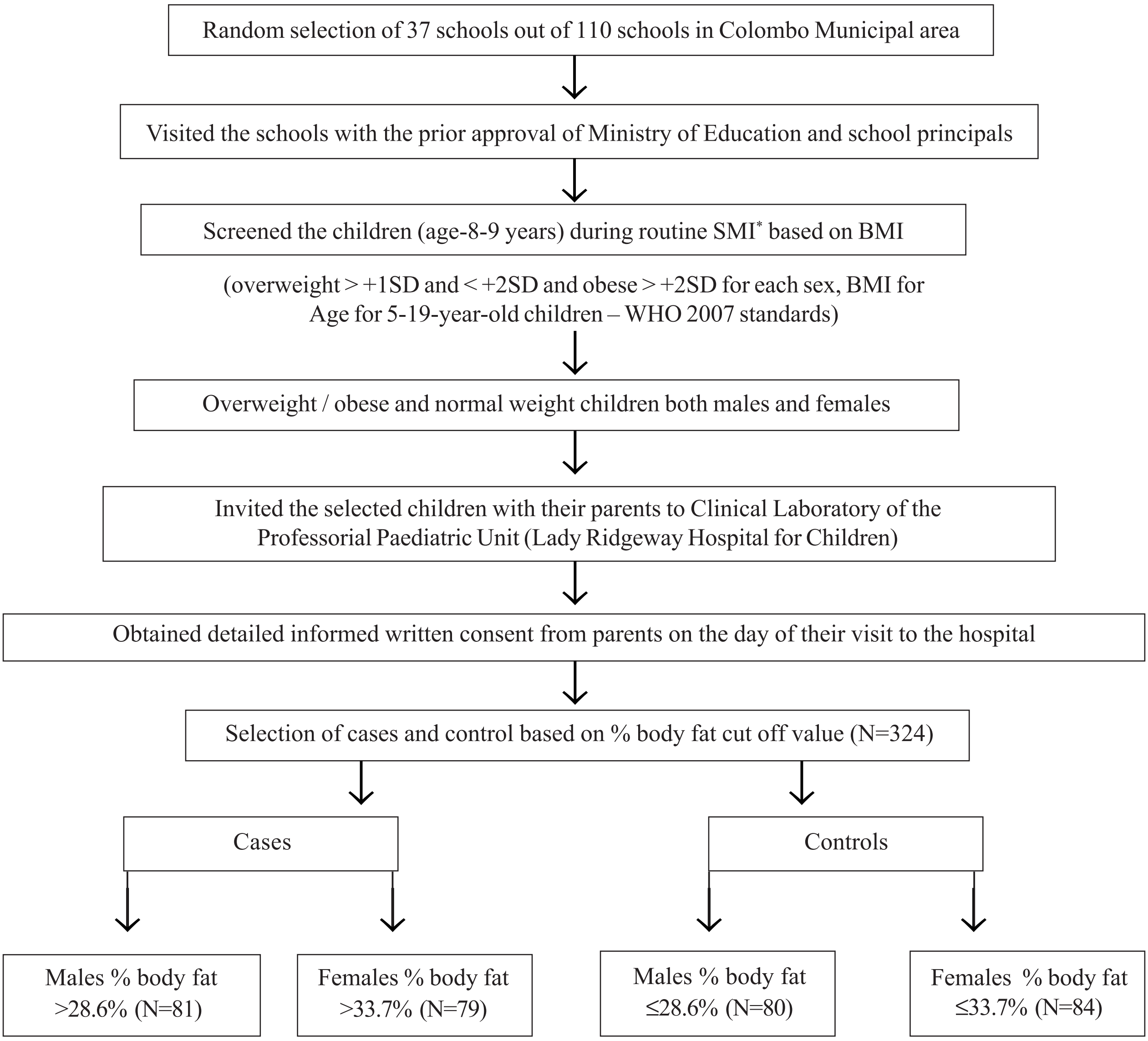

Figure 1. Subject recruitment flow chart (SMI* – School Medical Inspection, BMI – Body Mass Index). SMI is annually conducted in all government and semi government schools in Colombo Municipal area with routine health checkup, referring or treating identified ailments and carrying out immunization programmes for the children in grades 1, 4 and 7.

The body fat derived by this instrument has been previously validated against two population specific equations in a cohort of Sri Lankan children [15]. Furthermore, direct body composition measurements (fat mass [FM] and total body water [TBW]) obtained from the InBody 230® BIA machine was validated against the impedance values obtained from a BIA device (ImpediMed SFB7®; US 229-DF50, ImpediMed Ltd, Australia) and calculated using a population specific BIA equation [23] in a sub sample (N=26) of the current study population. Body composition assessed by InBody 230® showed a good correlation with the values calculated using impedance values assessed by ImpediMed® (FM $r=0.977$, $p<0.001$, TBW $r=0.748$, $p<0.001$).

Assessing socio-demographic and economic status

Socio-demographic data of the child were obtained from caregivers using an interviewer-administered questionnaire.

Assessment of dietary intake and habits

Dietary intake and habits were collected from caregivers using an interviewer-administered questionnaires. Dietary intake was assessed using a food frequency questionnaire (FFQ) validated for this population. The details of development and validation of the FFQ have been published elsewhere [24]. The FFQ assesses the consumption frequency and portion sizes of 106 food items including confectionery, savory items and sweetened carbonated beverages. Validated food portion size photographs [25] and household utensils (bowls, cups and spoons) where photographs were not available were used to estimate portion sizes. The dietary habits included were, the number of unhealthy snacks/days, snacking in the school environment, eating while watching television, skipping meals and consuming main meals away from home.

Assessment of physical activity

Physical activity was measured using the children physical activity questionnaire (C-PAQ) [26] with culturally sensitive modifications where relevant. The physical activity questionnaire was validated using content (similar as for the FFQ), and the criterion (against the accelerometer-ActiGraph wGT3x-BT® triaxial accelerometers) validity methods and the test-retest reliability were assessed by administering the questionnaire to the same study population two times one week apart [24]. Physical activity was measured during a typical school week inclusive of both weekdays and weekends. The investigator completed the questionnaire by interviewing the caregivers on the frequency and total time (in minutes) spent on each vigorous (Metabolic equivalent-MET value >6) physical activity [27] and sedentary behaviour (MET value 1.5) [28] by the child during the previous week.

Statistical analysis

Statistical analysis was performed using SPSS for windows version 20. The analysis was separately done for males and females. Chi-square analysis was used to analyze the categorical independent variables. Bivariate and multivariate binary logistic regression analysis was used to analyse the association between adiposity and socio-demographic, economic and lifestyle factors. Bivariate analysis was performed where the independent variables were entered one at a time, and crude odds ratios (COR) and 95%CIs were calculated. Multivariate analysis was used where all the independent variables were entered simultaneously, and AOR and 95%CIs were calculated after controlling for the confounding effect of all independent variables. Statistical significance was set at $p<0.05$.

Results

The validity of direct assessment of fat mass by InBody 230® and the fat mass calculated by a population specific BIA equation [23] (using the raw impedance values obtained by the same device) was assessed. The fat mass values had a significant correlation of $r>0.9$ ($p<0.001$) and intra-class correlation coefficient (ICC) of >0.9 (Supplementary Table S1).

Table 1 shows the socio-demographic characteristics of both cases and controls. The mean age of the study population was 9.14±0.31 years. There was no difference in age between cases and controls among both genders. A higher percentage of the children among female cases ($p<0.05$) had a high (>3.5kg) birth weight compared with their control group. However, there was no difference between male cases and controls.

Among male cases, majority (both father and mother) had at least primary education ($p<0.001$), were employed ($p<0.05$), had a high (≥55,000.00 LKR) household income ($p<0.001$) and owned a vehicle ($p<0.001$) compared to the controls. However, no such differences were seen among females, except for a high household income ($p<0.05$) among cases than controls. A higher percentage of male cases had fewer siblings ($p<0.01$), and their household size was smaller ($p<0.05$) compared to controls, whereas there were no such differences among females.

Table 2 describes the dietary habits and physical activity patterns of cases and controls. A significantly higher percentage of female cases consumed unhealthy snacks (>2/day) and more sweetened carbonated beverages (>240mL/day) compared to the controls, while there was no difference between male cases and controls. The percentage of male cases ($p<0.05$) who had unhealthy snacks in the school environment and watched television while eating was higher than the controls.

Further analysis on daily median intake of vegetables, fruits, energy and carbohydrate is denoted in Supplementary Table S2; no difference was seen in the daily intake of vegetables and fruits between cases and controls in both genders. The energy and carbohydrate intake was higher among female cases ($p<0.01$) than controls, while there was no difference among the males.

Cases from both genders ($p<0.001$) spent <3 times/week on vigorous physical activities and >2 hours/day on screen activities compared to the controls. However, a higher percentage of males from the control group ($p<0.05$) spent >2 hours/day on non-screen sedentary activities than cases, while in female cases spent >2 hours/day on non-screen sedentary activities compared to their control group.

Table 3 shows the socio-demographic, economic, dietary and physical activity predictors associated with high adiposity. Multivariate logistic regression analysis showed females with high birth weight (>3.5kg) (AOR 10.57 95%CI 1.65-67.84) were nearly 11 times more likely to have high body fat. Males from families with high household income (>55,000.00 LKR) (AOR 3.20 95% CI 1.25-8.20) were three times more likely to have a high body fat than the males from low income (≤55,000.00 LKR) families.

Table 1. Socio-demographic characteristics of cases and controls (N=324)

Characteristics	Males			Females		
	Cases N=81	Controls N=80	p value	Cases N=79	Controls N=84	p value
% BF (Median, IQR)	35.8 (31.5, 40.2)	16.26 (12.6, 24.1)	<0.001[a*]	38.4 (35.5, 42.2)	20.7 (15.5, 27.1)	<0.001[a**]
Age (Mean±SD)	9.11±0.323	9.21±0.356	0.069[b*]	9.13±0.266	9.11±0.292	0.572[b**]
Birth weight (BW) N(%)						
Low BW (<2.5kg)	6 (7.4)	11 (13.8)	0.340[*]	10 (12.7)	19 (22.6)	0.012[**]
Normal BW (2.5-3.5kg)	62 (76.5)	54 (67.5)		53 (67.1)	60 (71.4)	
Large BW (>3.5kg)	13 (16.0)	15 (18.8)		16 (20.3)	5 (6.0)	
Education and employment status N(%)						
Father						
Completed at least primary education	74 (91.4)	56 (70.0)	<0.001[*]	70 (88.6)	74 (88.1)	0.919[**]
Not completed	7 (8.6)	24 (30.0)		9 (11.4)	10 (11.9)	
Mother						
Completed at least primary education	75 (92.6)	59 (73.8)	<0.001[*]	64 (81.0)	74 (88.1)	0.210[**]
Not completed	6 (7.4)	21 (26.3)		15 (19.0)	10 (11.9)	
Both employed	18 (22.2)	8 (10.0)	0.035[*]	31 (39.2)	21 (25.0)	0.051[**]
One parent employed	63 (77.8)	72 (90.0)		48 (60.8)	63 (75.0)	
Monthly household income (LKR) N(%)						
≥55,000.00	46 (56.8)	14 (17.5)	<0.001[*]	27 (34.2)	14 (16.7)	0.01[**]
<55,000.00	35 (43.2)	66 (82.5)		52 (65.8)	70 (83.3)	
Number of siblings N (%)						
No/1 sibling	36 (44.4)	19 (23.8)	0.006[*]	33 (41.8)	29 (34.5)	0.341[**]
>1 siblings	45 (55.6)	61 (76.3)		46 (58.2)	55 (65.5)	
Having a vehicle N (%)						
Yes	61 (75.3)	34 (42.5)	<0.001[*]	50 (63.3)	56 (66.7)	0.652[**]
No	20 (24.7)	46 (57.5)		29 (36.7)	28 (33.3)	
Household size N (%)						
≤4 members	31 (38.3)	18 (22.5)	0.03[*]	27 (34.2)	31 (36.9)	0.716[**]
>4 members	50 (61.7)	62 (77.5)		52 (65.8)	53 (63.1)	

% BF – Percentage body fat. Pearson chi-square value significant at $p<0.05$ [*]Difference between male cases and controls, [**]Differences between female cases and controls. Mean value was compared using [b]independent sample-t-test, Median (interquartile range) was compared using [a]Mann-Whitney U test. The monthly income categories were based on the mean household expenditure per month in Sri Lanka – household income and expenditure survey 2016. LKR – Lankan rupees

Table 2. Dietary habits and physical activity patterns of cases and controls N=324

Characteristics	Males Cases N=81	Males Controls N=80	Males p value	Females Cases N=79	Females Controls N=84	Females p value
No of unhealthy snacks/day						
≤2 snacks	74 (91.4)	69 (86.3)	0.304*	52 (65.8)	72 (85.7)	0.03**
>2 snacks	7 (8.6)	11 (13.8)		27 (34.2)	12 (14.3)	
Habit of eating unhealthy snacks in the school environment						
Yes	43 (53.1)	27 (33.8)	0.013*	21 (26.6)	20 (23.8)	0.683**
No	38 (46.9)	53 (66.3)		58 (73.4)	64 (76.2)	
Habit of eating while watching TV						
Yes	28 (34.6)	14 (17.5)	0.014*	24 (30.4)	15 (17.9)	0.061**
No	53 (65.4)	66 (82.5)		55 (69.6)	69 (82.1)	
Skipping meals						
Yes	3 (3.7)	10 (12.5)	0.041*	7 (8.90)	13 (15.5)	0.198**
No	78 (96.3)	70 (87.5)		72 (91.1)	71 (84.5)	
Food away from home						
Yes	6 (7.4)	13 (16.3)	0.082*	13 (16.5)	8 (9.5)	0.187**
No	75 (92.6)	67 (83.8)		66 (83.5)	76 (90.5)	
Consumption of sweetened carbonated beverages						
<=240mL/day	65 (80.2)	62 (77.5)	0.669*	55 (69.6)	76 (90.5)	0.001**
>240mL/day	16 (19.8)	18 (22.5)		24 (30.4)	8 (9.5)	
Consumption of confectioneries/week						
never/rarely	26 (32.1)	15 (18.8)	0.205*	21 (26.6)	20 (23.8)	0.230**
1-2 times	28 (34.6)	28 (35.0)		25 (31.6)	25 (29.8)	
3-4 times	10 (12.3)	15 (18.8)		5 (6.3)	14 (16.7)	
>4 times	17 (21.0)	22 (27.5)		28 (35.4)	25 (29.8)	
Consumption of savory snacks/week						
never/rarely	45 (55.6)	43 (53.8)	0.271*	40 (50.6)	31 (36.9)	0.278**
1-2 times	20 (24.7)	18 (22.5)		24 (30.4)	32 (38.1)	
3-4 times	11 (13.6)	7 (8.8)		10 (12.7)	11 (13.1)	
>4 times	5 (6.2)	12 (15.0)		5 (6.3)	10 (11.9)	
Vigorous physical activity						
≥3 times per week	23 (28.4)	52 (65.0)	<0.001*	28 (35.4)	52 (61.9)	0.001**
< 3 times per day	58 (71.6)	28 (35.0)		51 (64.6)	32 (38.1)	
Screen time hours						
≤2 hours per day	50 (61.7)	71 (88.8)	<0.001*	31 (39.2)	72 (85.7)	<0.001**
>2 hours per day	31 (38.3)	9 (11.3)		48 (60.8)	12 (14.3)	
Non-screen sedentary activity						
≤2 hours per day	34 (42.0)	21 (26.3)	0.035*	22 (27.8)	38 (45.2)	0.021*
>2 hours per day	47 (58.0)	59 (73.8)		57 (72.2)	46 (54.8)	

Confectioneries – Cake, ice cream, chocolates, puddings, savoury item – Commercially available savoury items, fried savoury items, popcorn, potato and maniac chips, Unhealthy snacks – Biscuits, fried snacks. Vigorous physical activities – The activities with MET value >6 [27]. Screen activities – Viewing television, playing video games, using computers and other hand held electronic devices such as phones and I-pads. Non-screen sedentary activities – Drawing, reading, doing homework, listening to music, playing cards, sitting and talking and travelling in a vehicle.

Pearson chi-square value significant at p<0.05. All values are given as N(%)

*Difference between male cases and controls, **Differences between female cases and controls
Sweetened carbonated beverages categories (8OZ=240mL) [39].

Table 3. Socio demographic, economic and lifestyle predictors of high adiposity among primary school children (N=324)

	Males		Females	
Risk factors	COR 95%CI	AOR 95%CI	COR 95%CI	AOR 95%CI
Birth weight (BW)				
Low BW (<2.5kg)	Reference	Reference	Reference	Reference
Normal BW (2.5-3.5kg)	2.10 (0.73-6.07)	2.41 (0.51-11.36)	1.68 (0.72-3.93)	2.44 (0.66-9.04)
Large BW (>3.5kg)	1.59 (0.46-5.50)	1.40 (0.25-8.01)	6.08 (1.72-21.50)	**10.57 (1.65-67.84)**
Education level (Father)				
Completed at least primary education	4.53 (1.82-11.26)	1.98 (0.57-6.86)	1.05 (0.40-2.74)	0.94 (0.20-4.52)
Not completed primary education	Reference	Reference	Reference	Reference
Education level (Mother)				
Completed at least primary education	4.45 (1.69-11.73)	2.12 (0.52-8.53)	0.57 (0.24-1.37)	0.46 (0.13-1.70)
Not completed primary education	Reference	Reference	Reference	Reference
Employment status (Parents)				
Both employed	2.57 (1.05-6.32)	3.88 (1.03-14.66)	1.94 (0.99-3.78)	1.09 (0.39-3.08)
One parent employed	Reference	Reference	Reference	Reference
Monthly income (LKR)				
≥55000.00	6.20 (3.00-12.80)	**3.20 (1.25-8.20)**	2.59 (1.24-5.43)	2.23 (0.76-6.52)
<55,000.00	Reference	Reference	Reference	Reference
No of siblings				
No/1 sibling	2.56 (1.31-5.05)	1.88 (0.64-5.47)	1.36 (0.72-2.56)	2.97 (0.96-9.16)
>1 sibling	Reference	Reference	Reference	Reference
Household size				
≤4 members	2.13 (1.07-4.26)	2.01(0.59-6.82)	0.88 (0.47-1.69)	0.45 (0.16-1.22)
>4 members	Reference	Reference	Reference	Reference
Having a vehicle				
Yes	4.13 (2.11-8.08)	2.40 (0.91-6.34)	0.86 (0.45-1.64)	0.67 (0.24-1.82)
No	Reference	Reference	Reference	Reference
No of unhealthy snacks/day				
≤2 snacks	Reference	Reference	Reference	Reference
>2 snacks	0.59 (0.22- 1.62)	0.64 (0.16-2.63)	3.11 (1.44-6.71)	**3.16 (1.12-8.90)**
Habit of snacking in the school environment				
Yes	2.22 (1.18-420)	**3.20 (1.28-8.00)**	1.16 (0.57-2.35)	1.17 (0.40-3.46)
No	Reference	Reference	Reference	Reference
Habit of eating whilewatching TV				
Yes	2.49 (1.19-5.20)	0.66 (0.19-2.62)	2.00 (0.96-4.19)	0.99 (0.30-3.25)
No	Reference	Reference	Reference	Reference
Consumption of sweet carbonated beverage				
<=240 mL/day	Reference	Reference	Reference	Reference
>240 mL/day	0.85 (0.40-1.81)	1.64 (0.53-5.10)	4.14 (1.73-9.92)	**6.57 (1.88-22.92)**
Skipping meals				
Yes	2.57 (1.33-4.96)	0.53 (0.08-3.41)	1.36 (0.73-2.53)	0.44 (0.12-1.70)
No	Reference	Reference	Reference	Reference
Vigorous physical activity				
≥3 times per week	Reference	Reference	Reference	Reference
< 3 times per day	4.68 (2.40-9.12)	**3.48 (1.32-9.21)**	2.96 (1.56-5.60)	**2.92 (1.13-7.52)**
Screen time				
≤2 hours per day	Reference	Reference	Reference	Reference
>2 hours per day	4.89 (2.14-11.17)	**8.97 (2.59-31.09)**	9.29 (4.34-19.86)	**11.22 (4.24-29.64)**
Non screen sedentary activity				
≤2 hours per day	Reference	Reference	Reference	Reference
>2 hours per day	0.49 (0.25-0.95)	0.52 (0.20-1.38)	2.14 (1.11-4.11)	**3.81 (1.35-10.77)**

Bivariate and multivariate logistic regression analysis

COR – Crude odd ratio, AOR – Adjusted odd ratio, (After adjusting for all the independent variables included in the model)

CI – Confidence interval

Females who consumed unhealthy snacks (>2/day) (AOR 3.16 95%CI 1.12-8.90) had a threefold greater risk of having high body fat than the children who had ≤2 snacks/day, whereas no such association was seen among males. However, the males who had snacks in the school environment (AOR 3.20 95%CI 1.28-8.00) had a 3 times greater risk of having high body fat. The females who consumed sweetened carbonated beverages (>240mL/day) (AOR 6.57 95%CI 1.88-22.92) were nearly 7 times more likely to have high body fat.

Males who spent <3 times/week on vigorous physical activities (AOR 3.48 95%CI 1.32-9.21) were 3 times more likely to have a high body fat than those who spent ≥3 times/week. Females who spent <3 times/week on vigorous physical activities were nearly 3 times more likely to have a high body fat (AOR 2.92 95% CI 1.13-7.52). Both males (AOR 8.97 95%CI 2.59-31.09) and females (AOR 11.22 95%CI 4.24-29.64) who spent more than the recommended time (≤2 hours/day) on-screen activities were at 9 and 11 times greater risk of having high body fat, respectively. Similarly, females who spent more time (>2 hours/day) on non-screen sedentary activities (AOR 3.81 95%CI 1.35-10.77) were at nearly 4 times greater risk of developing high body fat than those who spent <2 hours/day. However, no such association was seen among males.

Discussion

The present case-control study focused on socio-demographic and lifestyle factors associated with adiposity among primary school children. The selection of cases and controls were based on body fat which was directly measured from InBody 230 multi-frequency analyzer. As there were no InBody 230 BIA device-based prediction equations for Sri Lankan children, validity assessments of direct measures were performed and they showed good reliability for body composition measurements in Sri Lankan children (Supplementary Table S1). Measurements obtained using this instrument creates minimal participant burden and high compliance, whilst also being cost effective (no electrodes required).

High household income, parent's education level, working parents and possession of a vehicle in the family among cases indicate that a higher socio-economic background is associated with BF. This is contrary to what is seen in developed countries where obesity prevalence is high among lower socio-economic groups. However, a similar finding has been reported among primary school children in China [29]. Further, our results indicate household income as a determinant of high adiposity, and a similar finding has been reported among school children from an urban area in Bangladesh [30]. A positive association was seen between high birth weight and adiposity only among females in the present study. A similar pattern of association has been reported among females in a previous study [31], whereas another study has reported a positive association among males [32]. Thus, more studies are needed to confirm the sex difference in the association between birth weight and childhood obesity.

Children with fewer siblings (≤1) and small household size (≤4) were more frequently seen among cases, and similar findings have been reported among Japanese children [33]. Further, the bivariate analysis showed an association between body fat and the number of siblings and household size. Moreover, less engagement in vigorous physical activity (<3 times/week) and high sedentary behaviours (≥2 hours/day) were more prominent among cases compared to the controls, and they were positively associated with adiposity. Having fewer siblings in the family is likely to reduce the possibility of interactive and team play among children. Due to a lack of playmates, they may engage in more sedentary activities than being physically active [34]. Higher socio-economic status among cases is likely to have increased their access to electronic devices such as computers, smartphones and video games, which would promote sedentary behaviour than physical activity.

A higher percentage of cases had unhealthy snacking (>2 snacks/day), snacking in the school environment, eating in front of the television screen and consuming sweetened carbonated beverages (>240mL/day) compared to the controls in the present study. Also, males and females who ate unhealthy snacks in the school environment and consumed >2 unhealthy snacks/day were three times more likely to have high body fat. Females who consumed more sweetened carbonated beverages were seven times more at risk of having a high body fat than the children with low consumption. A similar positive association has been reported among boys in Saudi Arabia [35]. Children have been reported to consume excess energy through unhealthy eating behaviours, which link them to the risk of obesity [36].

In addition, the energy and carbohydrate intake of cases were higher compared to controls. However, the consumption of vegetable and fruits were lower than the recommendation (minimum of 400g/day) [37] irrespective of body fat. Hence, the unhealthy snacking and sweetened carbonated beverages may have contributed to the weight gain among cases.

The habit of watching television while eating was frequently seen among male cases. The bivariate analysis showed a positive association between the practice of watching television while eating and body fat. The possible explanation for this finding could be that the increased energy intake with the television environment increases the duration of mealtime, which diminishes the control of satiety signals in response to the energy intake from the previous meal [38]. Furthermore, children pay less attention to their meals while watching television, which may lead them to eating excess quantities than their requirement. The present study could be representative of urban settings in Sri Lanka with a similar socio-economic background.

Limitations of the study

The findings of the present study may not be generalizable to all primary school children aged 8-9 years in Sri Lanka, which includes rural settings. All the measurements were based on subjective measures. Furthermore, the recall bias was unavoidable as the interview-based questionnaires were used to collect data for the past seven days, and cautious interpretation of results is suggested.

Conclusions

The present study identified birth weight, household income, unhealthy snacking, consumption of sweetened carbonated beverages, physical inactivity and sedentary behaviours as major predictors of body fat in this study population. Designing interventional programmes considering all modifiable risk factors and the environment (school and domestic) where the child is exposed to a wide range of eating behaviours are recommended.

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Abbreviations

BIA: Bioelectrical impedance analysis, COR: Crude odds ratios, AOR: Adjusted odd ratios, CI: Confidence interval, SMI: School medical inspection, BMI: Body mass index, FFQ: Food frequency questionnaire, C-PAQ: Children physical activity questionnaire, LKR: Sri Lankan rupees, MET: Metabolic equivalent

Competing interest

The authors declare that they have no competing interests.

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Consent for publication

Not applicable.

Ethics clearances

Ethics approvals were obtained from the Ethics Review Committees of the Faculty of the Medicine, University of Colombo (EC-14-168), Sri Lanka and the Lady Ridgeway Hospital, Sri Lanka. Approvals were obtained from the Ministry of Education and the Principals of Schools.

Authors' contribution

KT, PL, TT, PW and DS designed the study. KT carried out the study and the laboratory analysis, KT, DS, TT, PL and PW analyzed data and wrote the manuscript. PL edited the manuscript. All authors approved the final version of the paper.

Supplementary files

Table S1. Assessment of validity of body composition measurements by InBody 230

Method used to validate the body composition assessment results from InBody 230	Sample size (N)	Correlation (r) TBW	Correlation (r) FM	ICC (rI). TBW	ICC (rI). FM
Validation of InBody 230 measurements against Single frequency (50Hz) potable BIA device derived impedance values, applying Sri Lankan specific BIA equation [1]	26	0.748 $p<0.001$	0.977 $p<0.001$	0.853	0.970
Validation of InBody 230 measurements against Sri Lankan specific Height-weight equation [2]	324	0.885 $p<0.001$	0.931 $p<0.001$	0.938	0.916
Applying impedance values obtained from InBody 230 BIA device at 20Hz and 100Hz and applying Sri Lankan specific BIA equation [1]	324				
20Hz		0.895 $p<0.001$	0.940 $p<0.001$	0.908	0.912
100Hz		0.899 $p<0.001$	0.938 $p<0.001$	0.941	0.941

TBW – total body water, FM – Fat mass, BIA – Bioelectrical impedance analysis, FFM – Fat free mass
BIA specific impedance equations for Sri Lankan children – (TBW = 0.41 impedance index + 0.17 weight + 1.1 sex code + 0.44, FFM = 0.56 impedance index + 0.22 weight + 1.6 sex code – 0.22) [23]. *Height-weight population specific equation for Sri Lankan children* – (TBW = 0.12 Height + 0.26 weight + 1.2 sex code – 8.3, FFM = 0.16 Height + 0.36 weight + 3.0 sex code – 14.8) for Sri Lankan children [41]. Pearson correlation (r) and Intra class correlation (ICC-r(I) were used to assess the validity of direct body composition measures of InBody 230 against the other methods.

Table S2. Daily food and nutrient intake of cases and controls N=257

	Gender	Cases M(N=54)/F(N=63)	Controls M(N=63)/F(N=77)	p-value
Leafy vegetables (g/day)	Males	8.01(2.9, 18.9)	11.65 (2.9, 21.5)	0.607
	Females	10.20 (2.9, 20.4)	11.65 (2.9, 20.4)	0.824
Vegetables (g/day)	Males	39.41 (26.9, 51.6)	37.34 (23.2, 43.8)	0.457
	Females	31.60 (21.0, 48.0)	31.95 (21.1, 48.5)	0.657
Fruits (g/day)	Males	81.56 (41.7, 120.4)	67.36 (32.2, 128.6)	0.500
	Females	44.70 (17.8, 113.4)	63.68 (29.1, 104.2)	0.324
Energy intake/day	Males	1908.19 (1614.7, 2265.9)	1876.58 (1526.2, 2250.2)	0.299
	Females	2109.10 (1805.9, 2446.6)	1768.78 (1518.4, 2318.8)	0.003
CHO intake (g/day)	Males	299.28 (261.9, 371.1)	281.37 (228.9, 353.6)	0.149
	Females	336.90 (286.9, 390.2)	286.49 (234.8, 348.2)	0.004

CHO – carbohydrate
The total sample of N=257 included in this analysis of dietary nutrient intake after excluding the under reporters
The food and nutrient intakes of children whose daily energy intake (Total energy intake per week/7) was below [Basal metabolic rate – BMR ×1.2] [39] were excluded from the analysis.

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