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RESEARCH

Dietary Energy Consumption Pattern and Intake of Cholesterol and Dietary Fibre among 11-13 Year-old Children in the City of Colombo

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ABSTRACT

Childhood obesity is rising in the city of Colombo and the composition of children's diet, which has a direct link to it, has not been adequately investigated. Hence a cross-sectional study was conducted recruiting 634 school-children (11-13 year-old) using multistage stratified cluster sampling technique to assess dietary energy contribution from macronutrients, saturated fat (SF) and added sugar. In addition, cholesterol and fibre intake were estimated. Food and beverages consumed were recorded using a three-day diet-diary. Results indicated that, % energy from carbohydrate (%CHO) and cholesterol intake were within the recommendation while % energy from protein (%Protein) was below the recommendation. Intake of fibre was approximately 1/4th of the recommend level and energy from SF (%SF) and added sugar was above the recommendation, irrespective of gender, food security status and school type. The % energy contribution from fat (%Fat) among national school (NS) children was above the recommended level, while that of provincial school (PS) children remained within the recommendation. Boys consumed a higher %Protein, %Fat and %SF and cholesterol than girls ($p<0.05$) while girls had more %CHO and %energy from added sugar ($p<0.05$). Food-secure children consumed higher %Fat than food-insecure children ($p<0.05$). PS children had more %CHO and less %Protein, %Fat and %SF than NS children ($p<0.05$). In conclusion, 11-13 year old-children in Colombo city consume desirable level of CHO and cholesterol, although their dietary energy consumption from protein is inadequate. However, they consume undesirably high level of SF and added sugar while dietary fibre intake is very low.

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INTRODUCTION

The prevalence of child obesity has become an epidemic in both developed and developing countries where lifestyle preferences play a pivotal role in rising child obesity at an alarming rate (Sahoo et al., 2015). According to Davison et al. (2001), risk factors for childhood obesity include dietary intake, physical activity and sedentary behaviour which are moderated by age and gender. Child obesity is linked to many medical conditions, including fatty liver disease, sleep apnea, Type 2 diabetes, asthma, cardiovascular disease, high cholesterol, gallstones, glucose intolerance and insulin resistance, skin conditions, menstrual abnormalities, impaired balance, and orthopedic problems (Niehoff, 2009).

In Sri Lankan context, the highest prevalence of obesity among school children was reported in grade 7 school children (11-13 years) in the city of Colombo, with an increasing trend during past decades (FHB, 2019). The city of Colombo, the commercial capital of the country is in phase of rapid nutrition transition and consequently vegetable based diet has changed to animal based diet rich in energy, sugar and salt (Weerahewa et al., 2018). Fast foods and sugary drinks are identified as potential contributing factors for obesity (Anderson and Butcher, 2006). Macronutrients, i.e. carbohydrate, protein and fat, are the main sources of energy in the diet and percentage of energy from macronutrients influences the onset of overweight (de Menezes and Marucci, 2012). Furthermore, epidemiological and clinical studies have revealed that, consumption of dietary fiber is inversely related to obesity (Tucker and Thomas, 2009). Moreover, adipocyte hypertrophy is observed during the pathogenesis of obesity and adipocyte cholesterol accumulates as adipocytes undergo hypertrophy. Recent studies have suggested that, dietary cholesterol contributes to increased adipocyte cholesterol (Chung and Parks, 2016). In spite of that, dietary saturated fat intake accentuates obesity risk associated with the fat mass and obesity-associated gene (FTO) (Phillips et al., 2012).

Even though the diet of 11-13 year-old children has been analyzed for the intake of energy, macronutrients and micronutrients, studies analyzing dietary energy contribution from macronutrients, added sugar, saturated fats and the intake of cholesterol and dietary fibre are lacking. Hence, the current study was conducted to determine the energy contribution from macronutrients, saturated fat, added sugar and intake of cholesterol and dietary fibre among 11-13 year-old children in the city of Colombo.

METHODOLOGY

Subjects

Total of 634 children, aged 11-13 years was recruited for the study using multistage stratified cluster sampling technique. The strata were “administrative district” (North Colombo, Central Colombo A, Central Colombo B, Borella, East Colombo and West Colombo), “school type” (provincial school and national school) and “school category” (Sinhala medium, Tamil medium, Sinhala & Tamil media and Muslim school). A cluster sample of subjects in a single class room from each randomly selected school was drawn for the study.

Study design

A cross-sectional study was carried out using 11-13 year-old school children who were studying in grade 7 in 12 randomly selected schools from 113 schools (12,724 students) in the city of Colombo. Subjects who were unhealthy, living outside the Colombo city and living away from parents were excluded from this study. Accordingly, a total of 634 subjects were considered for the study.

Data collection

Consumption of foods and beverages

A self–administered three-day diet diary was used to collect information on time, place and types of foods and beverages taken, amounts of foods and beverages consumed in household measurements and preparation method of each food and beverage in three consecutive days, including two week days

and one weekend day. A comprehensive explanation of keeping records on diet diary and recording portion sizes of foods and beverages was given to the participants before distributing the diet diary, which was developed using household standard food models. Data collection was performed from May to November in 2019.

Household food security status

The translated forms (Sinhala and Tamil) of 18 item scale of USDA household food security/ hunger survey module questionnaire was self-administered to the mother or guardian of the subject with a reference period of past 12 months from the date of administration of the questionnaire, in order to measure household food security status of the subjects (Gary et al., 2000). 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".

Socio-demographic characteristics

Socio-demographic characteristics of subjects were gathered using a general questionnaire filled by the parent or guardian of the subject on ethnicity, household monthly income, size and living area and maternal level of education and paternal occupation.

Ethical clearance

Ethical clearance for the study was obtained from Ethical Clearance Committee of National Institute of Health sciences, Kalutara and a written consent was taken from the mother or guardian of the subject, prior to data collection.

Data analysis

Consumption of foods and beverages

G-conversion table developed for converting household measurements of Sri Lankan foods and beverages into grams and milliliters was used to convert the recorded amounts of foods and beverages consumed by each subject in household measurements into "grams" and "milliliters". Then, Foodbase 2000 software developed for analyzing composition of Sri Lankan foods and beverages was used to analyze the three-day diet diaries for fibre, cholesterol, % energy from fat, % energy from carbohydrate, % energy from protein, % energy from saturated fat and % energy from added sugar.

Household food security status

The affirmative responses were coded as "1" and negative responses were coded as "0" based on the USDA household food security/ hunger survey module (Gary et al., 2000). The summation of all the affirmative responses was used to determine the household food security status of the subjects. Subjects were categorized as "food secure" and "food insecure", based on the affirmative responses scored for the questionnaire as, 0-2 – food secure and 3-18 - food insecure.

Statistical analysis

The mean (±SD) dietary fibre, cholesterol and % energy from carbohydrate, protein, fat, saturated fat and added sugar were calculated and compared for the difference in gender, school type and household food security status using 2-independent sample t-test at the significant level of 0.05. All categorical socio-demographic data were analyzed for difference in gender, household food security status and school type using chi-squared test at significant level of 0.05. The statistical analyzes were performed using SPSS version 21 (SPSS Inc, Chicago, IL) statistical package.

RESULTS AND DISCUSSION

Characteristics of the subjects

The socio-demographic characteristics of the subjects by gender, household food security status and type of school are summarized in Table 1.

Dietary energy contribution from macronutrients, saturated fat, added sugar and the intake of dietary fibre and cholesterol

Gender difference

The study cohort consisted of 336 boys and 270 girls, and gender difference of dietary energy contribution from macronutrients, saturated fat, added sugar and intake of dietary fibre and cholesterol is summarized in Table 2.

The daily energy intake was below the recommended dietary allowance irrespective of gender (2562 kcal for boys and 2250 kcal for girls) and there was no gender difference in energy intake.

The percentage of energy consumption from carbohydrate in both boys and girls was within the recommended range of 45-65% and girls consumed 4.51% more energy from carbohydrates than boys ($p<0.001$). However, dietary energy contribution from protein was below the recommended range (15-20%) similar to 12-19 year-old Mexican children's diet, independent of gender, although boys consumed 0.53% more energy from protein than girls ($p<0.05$) (Rodríguez-Ramírez et al., 2009). In addition, energy contribution from fat among boys was slightly above the recommended level of 15-30%, reporting 3.63% more energy consumption from fat than girls whose energy contribution from fat was within the recommended level ($p<0.001$). The energy contribution from saturated fat and added sugar was above the recommended upper limits (saturated fat -10 % and added sugar- 5 %) irrespective of the gender. The dietary energy contribution from saturated fat among boys was twice as the upper limit and 3.26% higher than that of the girls ($p<0.001$). In contrast, percentage energy consumption from added sugar by girls was 1.96% higher than that of the boys ($p<0.05$). The boys consumed 34.55 mg more cholesterol compared to girls ($p<0.05$), although cholesterol intake of both boys and girls was within the acceptable level (below 300 mg). Both boys and girls consumed dietary fibre approximately $1/4^{th}$ of the recommended levels (boys -31 g; girls- 26 g). Greek urban children had higher saturated fat level and boys consumed more cholesterol than that of the girls, similar to our findings (Klimis-Zacas et al., 2007).

The greater consumption of energy from fat, saturated fat, cholesterol and protein among boys and added sugars among girls could be due to sex difference in craving for different types of foods, i.e. boys have more craving for savoury foods such as meat, fish, eggs, whereas, girls have more craving for sweet foods, which is driven by increased sex hormone levels during adolescent period (Hallam et al., 2016). In the city of Colombo, the prevalence of central obesity among 11-13 year-old boys was higher than that of girls, even though boys were more physically active than girls (Athauda et al., 2023). It might be a consequence of high % Fat, % SF and cholesterol intake among boys, which yield more energy in the body compared to sweet foods. According to Athauda et al. (2022), relatively lower percentage of 11-13 year-old children in the city of Colombo consumed fruits and vegetables (dark green leafy vegetables, vitamin A rich fruits and vegetables and other fruits and vegetables were 17.7 %, 29.5 % and 64.3 % respectively), which are the main sources of dietary fibre in the diet, which could be the cause for inadequate intake of dietary fibre among both girls and boys.

Difference by household food security status

The sample comprised 225 food secured children and 146 food insecure children and the difference in dietary energy contribution from macronutrients, saturated fat, added sugar and intake of cholesterol and dietary fibre by household food security status is shown in Table 3.

Table 1. Socio-demographic characteristics of subjects by gender, household food security status and type of school

Characteristic of the subject		Type of school			Household Food Security Status			Gender	
		National school (%)	Provincial school (%)		Food secure (%)	Food Insecure (%)		Boys (%)	Girls (%)
Ethnicity	(n=513)[1]			(n=369)[1]			(n=513)[1]		
Sinhalese		35.48	19.88		42.3	15.4		35.48	19.88
Tamil		10.33	4.68		7.6	9.2		10.33	4.68
Muslim		3.51	29.0		10.6	14.1		3.51	29.00
Other		0.20	0.38		0.3	0.5		0.20	0.38
Household size	(n=384)[1]			(n=356)[2]			(n=384)[1]		
Below 5		23.44	13.54		25.28	14.33		23.44	13.54
Between 5 - 8		26.82	29.17		31.18	22.75		26.82	29.17
Above 8		1.30	5.73		3.65	2.81		1.30	5.73
Household monthly income	(n=387)[1]			(n= 362)[1]			(n=387)[1]		
Below LKR 25 000		10.08	16.02		8.6	17.1		10.08	16.02
LKR 25 001 – 50 000		13.95	18.35		17.7	14.6		13.95	18.35
LKR 50 001 – 75 000		10.85	6.46		12.2	5.2		10.85	6.46
LKR 75 001 – 100 000		8.01	4.91		11.3	1.9		8.01	4.91
Above LKR 100 000		9.56	1.81		10.5	0.8		9.56	1.81

Table 1. Continued

Characteristic of the subject		Type of school		Household Food Security Status			Gender	
		National school (%)	Provincial school (%)		Food secure (%)	Food Insecure (%)	Boys (%)	Girls (%)
Maternal education	(n=388)[1]			(n=360)[1]			(n=388)[1]	
No schooling		1.03	0.77		0.8	1.1	1.03	0.77
Grade 1 – 5		1.29	4.64		2.2	3.6	1.29	4.64
Grade 6 – 10		5.93	14.69		6.7	12.2	14.69	5.93
Ordinary level (O/L)		9.28	13.14		12.8	10.0	9.28	13.14
Advanced level (A/L)		19.33	9.54		22.2	7.2	9.54	19.33
Diploma / Degree		15.21	5.15		16.4	4.7	5.15	15.21
Paternal occupation	(n=361)[1]			(n=332)[1]			(n=361)[1]	
No		1.66	2.49		3.01	1.20	1.66	2.49
Labourer		5.54	9.70		4.22	10.24	5.54	9.70
Self- employment		19.11	19.67		22.59	15.96	19.11	19.67
Non- Executive		8.31	8.59		11.75	6.02	8.31	8.59
Executive		17.17	5.82		19.88	3.61	17.17	5.82
Abroad		0.83	1.11		0.60	0.90	0.83	1.11

[1] Significantly different by chi-squared test ($p<0.001$) [2] No significant difference by chi-squared test ($p>0.05$)

Table 2. Gender difference of average (±standard deviation) dietary energy contribution from macronutrients, saturated fat, added sugar and intake of cholesterol and dietary fibre among 11-13 year old children in the city of Colombo

Nutrient/ Compound	Boys	Girls	p value[1]
Energy (kcal)	1698.43 ±425.02	1645.49 ± 551.27	0.441
Dietary fibre (g)	7.48 ± 3.22	6.93 ± 4.25	0.297
Cholesterol (mg)	152.19 ±106.73	117.64 ± 93.54	0.011
Energy from carbohydrate (%)	56.94 ± 8.84	61.45 ± 7.04	<0.001
Energy from protein (%)	12.20 ± 1.98	11.67 ± 1.72	0.035
Energy from fat (%)	30.46 ± 7.43	26.83 ± 6.79	<0.001
Energy from saturated fat (%)	20.46 ± 5.75	17.20 ± 5.92	<0.001
Energy from added sugar (%)	6.11 ± 3.94	8.07± 4.83	0.002

[1] Significance of gender on measured parameter was tested by 2-independent sample t test at p=0.05.

Table 3. The average (±standard deviation) dietary energy contribution from macronutrients, saturated fat, added sugar and intake of cholesterol and dietary fibre among 11-13 year-old children in the city of Colombo by household food security status

Nutrient/ Compound	Food secure	Food insecure	p value[1]
Energy (kcal)	1669.02 ± 455.38	1685.97 ± 549.64	0.825
Dietary fibre (g)	7.11 ± 3.54	7.74 ± 4.02	0.270
Cholesterol (g)	148.85 ± 104.79	120.32 ± 92.36	0.053
Energy from carbohydrate (%)	57.63 ± 8.55	60.44 ± 8.10	0.022
Energy from protein (%)	12.08 ± 2.02	11.80 ± 1.73	0.301
Energy from fat (%)	29.94 ± 7.07	27.66 ± 7.81	0.043
Energy from saturated fat (%)	19.72 ± 5.59	18.32 ± 6.78	0.140
Energy from added sugar (%)	7.14 ± 4.66	6.92 ± 3.96	0.723

[1] Significance of food security status on measured parameter was tested by 2-independent sample t test at p=0.05.

Energy intake did not meet the recommended dietary allowance of this age group. However, energy intake from saturated fat and added sugar was above the recommended upper limit and protein intake was below the recommended level, independent of the household food security status. The reported higher intake of energy from saturated fat could be due to wide use of coconut for preparation of curries and coconut oil and palm oil for preparation of fatty foods in Sri Lanka, even among low income households, which are relatively cheap and high in saturated fats (Samarajeewa and Gunathilake, 2002). Relatively high cost of animal protein sources and larger household size would be a reason for unaffordability and consumption of small portion size of protein sources, without any difference in household food security status (HARTI, 2019). The intake of cholesterol and dietary energy contribution from carbohydrates and fat were within the desirable limits, independent of the household food security status. However, food insecure children consumed 2.81% more energy from carbohydrates compared to food secure children, whereas consumption of energy from fat by food secure children was 2.28 % higher than their counterpart ($p<0.05$). Food secured children had higher household

monthly income compared to food insecure children in this study. Therefore, affordability of food secured children to purchase high-priced fast foods rich in fat, such as fried rice, *kottu, parata*, increased. While food insecure children could afford only starchy foods which are cheap such as buns, bread, *Thosai*, string hoppers and *pittu*. Further, the dietary fibre intake was lower than 1/4th of the recommended intake in both food secure and food insecure children in the city of Colombo.

Difference by school type

The number of children participated in the study from provincial and national schools was 330 and 272 respectively and the difference in dietary energy contribution from macronutrients, saturated fat, added sugar and the intake of dietary fibre and cholesterol by school type is illustrated in Table 4.

Even though energy consumption is below the recommendation, percentage energy consumed from carbohydrate was within the acceptable limit whereas, percentage energy consumed from saturated fats and added sugar was above the upper limits, irrespective of the school type. Indeed, percentage energy consumption from carbohydrate among provincial school children was slightly below the upper limit and 8.74% greater than that of the national school children ($p<0.001$) whose dietary energy distribution from carbohydrate was at the most desirable level (55%).

Furthermore, national school children consumed 0.82% more energy from protein compared to that of provincial school children ($p<0.001$), even though their energy consumption from protein was well below the recommended level. In contrast, national school children consumed three folds and provincial school children consumed two folds of the recommended upper limit of fat ($p<0.001$). Moreover, children studying in national schools had 6.66% more energy from saturated fat than children studying in provincial schools ($p<0.001$). Even though cholesterol intake was lower than the upper limit, in both groups, national school children consumed almost double the intake of cholesterol compared to provincial school children ($p<0.001$). Dietary fibre intake was approximately one fourth of the recommendation in both the groups without any difference in school type.

According to our study, national school children had greater affordability than provincial school children and consequently, they could afford high priced fatty fast foods, and thus, more fat, saturated fat and cholesterol than provincial school children, who could afford only cheap starchy foods. Even though dietary energy contribution from added sugar was above the desirable limit in both categories in the current study, it is lower than the added sugar consumption of Sri Lankan preschoolers, which was 21.1% of dietary energy (Mututanthri et al., 2022).

Table 4. The average (±standard deviation) dietary energy contribution from macronutrients, saturated fat, added sugar and intake of cholesterol and dietary fibre among 11-13 year-old children in Colombo city by type of school

Nutrient/ Compound	Provincial Schools	National Schools	p value[1]
Energy (kcal)	1745.70 ± 579.25	1644.73 ± 420.86	0.186
Dietary fibre (g)	7.33 ± 4.60	7.22 ± 3.16	0.855
Cholesterol (g)	84.23 ± 74.14	164.29 ±104.78	<0.001
Energy from carbohydrate (%)	64.65 ± 6.44	55.91 ± 7.82	<0.001
Energy from protein (%)	11.43 ± 1.35	12.25 ± 2.06	<0.001
Energy from fat (%)	23.88 ± 6.30	31.47 ± 6.57	<0.001
Energy from saturated fat (%)	14.66 ± 5.06	21.32 ± 5.20	<0.001
Energy from added sugar (%)	7.68 ± 4.10	6.52 ± 4.52	0.055

[1] Significance of school type on measured parameter was tested by 2-independent sample t test at p=0.05 and p=0.001

Previous studies have revealed that protein was the most satiating macronutrient followed by carbohydrate and the least by fat (Stubbs et al., 2000). According to Stubbs et al. (2023), high fat, energy dense foods induce higher levels of energy consumption than low fat, less energy dense foods. Moreover, it has been hypothesized that lipids in food are the primary regulator of energy balance (Beglinger, 1994). Therefore, reported high fat and low protein diet among 11-13 year-old children in the city of Colombo could lead to overconsumption of foods. In spite of that, it has been revealed that, dietary fibre is inversely related to obesity, while dietary saturated fat intake accentuates obesity risk associated with the fat mass and obesity-associated gene (FTO) (Phillips et al., 2012). Previous studies conducted in the city of Colombo using the same age group reported that the dietary energy intake did not meet the recommended level (Kumuduni et al., 2008; Athauda et al., 2022). Hence, high intake of saturated fat and low intake of dietary fibre could be contributory factors for high prevalence of obesity reported among 11-13 year-old children in the city of Colombo.

Since adolescents are more vulnerable to media and peer influence than parents, skipping breakfast, snacking, consuming fast foods from restaurants and fast food chains and consuming sweet and high-energy drinks remain common among adolescents (De Vet et al., 2015; Das et al., 2017). Hence, observed low fibre and high saturated fat containing food consumption among children in adolescence period, irrespective of the gender, food security status and school type, could be, in part, due to media and peer influence on dietary habits.

CONCLUSION

In conclusion, during the study period 11-13 year-old school-children in the city of Colombo consumed a diet comprising desirable level of energy from carbohydrate, although energy consumption from protein was inadequate. However, dietary energy contribution from saturated fat and added sugar was undesirably high. Even though their cholesterol intake was desirable, dietary fibre intake was very low.

Further studies should be conducted in the city of Colombo to assess the relationship among dietary energy contribution from macronutrients and added sugar and the intake of dietary fibre, and overnutrition among adolescents, who have exhibited an alarming trend of overweight and obesity.

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