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Research Article

Hidden hunger: A case in early adolescents of the Colombo city

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Abstract: Hidden hunger is the chronic deficiency of essential vitamins and minerals, collectively known as micronutrients. Globally two billion people are in hidden hunger. The prevalence of hidden hunger is high in developing countries, and adolescents were found to be one of the most vulnerable populations. The prevalence of overnutrition in early adolescents in Colombo city has been rising during the past decades, and the vegetable-based diet has been shifted to an animal-based diet due to the rapid nutrition transition. Therefore, a cross-sectional study was conducted using early adolescents aged 11-13 years in Colombo city to determine the adequacy of micronutrient intake. Six hundred thirty-four subjects were recruited using the multistage stratified cluster sampling technique. Socio-demographic data were collected using a general questionnaire. Dietary intake data were gathered using a three-day diet diary. Diet diaries were analyzed for daily energy, protein, and micronutrient intake using FoodBase 2000 software. The mean intake of energy, protein, and micronutrients was compared with the Recommended Dietary Allowance (RDA) values, and the percentage of subjects below the RDA of the nutrient was determined. Results revealed that energy and micronutrient intake of calcium, iron, zinc, magnesium, iodine, vitamin A, thiamin, riboflavin, vitamin B_{12}, folate, and vitamin C were below the RDA value. Daily intake of protein, selenium, and niacin met the RDA. Daily vitamin B_6 intake reached the RDA value in girls and was inadequate in boys. The highest percentage of scarce minerals and vitamins were iron and folate, respectively. Thus, early adolescents aged 11-13 years in the city of Colombo are in hidden hunger.

Keywords: Early adolescents, hidden hunger, micronutrients, Recommended Dietary Allowance (RDA).

1. Introduction

Hidden hunger is the chronic deficiency of essential vitamins and minerals known as micronutrients. Iron, zinc, vitamin A, iodine, and folate are the most widespread micronutrient deficiencies in the world (Muthayya et al., 2013). Micronutrients are required in minute quantities and play a vital role in normal human growth and development, physiological functioning, and maintenance of health (Shergill-Bonner, 2017). Dietary intake of micronutrients is essential as they are not synthesized in the human body. Inadequate intake of micronutrients from the diet can result in adverse health consequences, such as decreased immunity, impaired cognitive performance, stunted growth, and increased morbidity and mortality (Abeywickrama et al., 2018).

Globally, two billion people are in hidden hunger (Muthayya et al., 2013). Hidden hunger is high in developing countries, and adolescents were among the most vulnerable populations (Muthayya et al., 2013; Bailey et al., 2015; Shergill-Bonner, 2017). The prevalence of iron deficiency among 10 - 14 years in Sri Lanka in 2017 was 18.2%, and girls were more prevailed than boys. The prevalence of zinc deficiency in this age group was 29.3% in 2017 in Sri Lanka (Jayatissa et al., 2019).

The nutrient requirement of early adolescence is high due to the high growth rate, and sexual maturity of life occurs during that period. The city of Colombo, the capital of Sri Lanka, is in a rapid nutrition transition. Therefore, the vegetable-based diet was replaced by an animal-based diet which is rich in energy, sugar, and salt (Weerahewa et al., 2018). Further, the prevalence of obesity and overweight among adolescents in Colombo city rose during the past decade, indicating excess dietary energy intake (Family Health Bureau, 2020). However, fulfillment of their micronutrient requirement is still under question. Even though many studies were conducted to determine the prevalence and causes of overnutrition among adolescents in the city of Colombo, studies are lacking in determining their adequacy in micronutrient intake. Therefore, this study was conducted to determine the adequacy of dietary micronutrient intake of 11-13 year early adolescents in Colombo city.

2. Methodology

2.1. Study sample

A cross-sectional study was conducted in Colombo city using 634 adolescents aged 11-13 years who were studying in grade 7 of 12 national and provincial schools. The multistage stratified cluster sampling technique was used to recruit the subjects for the study. The strata were "Administrative district" (North Colombo, Central Colombo A, Central Colombo B, Borella, East

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Colombo, and West Colombo), "Type of school" (national and provincial schools), and "School category" (Sinhala medium, Tamil medium, Sinhala and Tamil media and Muslim schools). A proportionate sample of subjects in each stratum was recruited for this study. The number of subjects recruited from North Colombo, Central Colombo A, Central Colombo B, Borella, East Colombo, and West Colombo was 67, 114, 63, 233, 28, and 129, respectively. The subjects representing national schools were 327, and provincial schools were 307. Further, subjects from Sinhala medium, Tamil medium, Sinhala and Tamil media, and Muslim schools were 402, 51, 78, and 75, respectively. The subjects who were unhealthy, living outside the city of Colombo, and living apart from their parents were excluded from the study.

2.2. Data collection

Socio-demographic data

A pre-tested questionnaire was self–administered to the mother or guardian to collect socio-demographic information on ethnicity, gender, household size, level of education of parents, occupation of parents, monthly household income, and the household living area of the subject.

The monthly household income was categorized into five levels as "below LKR 25 000", "between LKR 25 000 – 50 000", "between LKR 50 001 – 75 000", "between LKR 75 0001 – 100 000", and "above LKR 100 000". The household living area was categorized into three levels as "below 126.46 m^2" (below 5 perches), "between 126.46 m^2 - 252.90 m^2" (5-10 perches), and "above 252.90 m^2" (above 10 perches). In addition to that, parental occupation was categorized into six as "No occupation", "Labourer", "Self- employment", "Non- Executive", "Executive", and "Abroad". The level of education of parents was categorized into six levels as "No schooling", "Grade 1-5", "Grade 5-10", "Ordinary Level (O/L)", "Advanced Level (A/L)" and "Diploma/Degree".

Daily intake of energy, protein, and micronutrients

A self-administered three-day diet diary was used to gather the amount and type of foods and beverages consumed in three consecutive days, including two week days and one weekend, to assess the daily energy, protein, and micronutrient intake of the subjects. This was done after a comprehensive explanation of keeping records in a diet diary and recording portion sizes of foods using household standard food models. The subjects recorded the time, venue, type, amount, and preparation of all the foods and beverages for 24 hours with the assistance of their mothers.

Ethical clearance

Ethical clearance for this study was obtained from the National Institute of Health Sciences Ethical Review Committee. A written informed consent was obtained from the mother or guardian of the subjects after informing them about the information gathered by the researcher.

2.3. Data analysis

Daily intake of energy, protein, and micronutrients

Three-day diet diaries were analyzed using FoodBase 2000 software available in the Department of Applied Nutrition, Wayamba University of Sri Lanka, after converting amounts of foods and beverages recorded in household measurements into SI units using the G- conversion table. Mean daily energy, protein, calcium, iron, zinc, magnesium, selenium, iodine, vitamin A, thiamin, riboflavin, niacin, vitamin B_6, vitamin B_{12}, folate, and vitamin C were determined using the FoodBase 2000 software and compared with the Recommended Dietary Allowance (RDA) of an average 11-13 year adolescent in Sri Lanka.

Recommended Dietary Allowance (RDA)

RDA of energy, protein, and micronutrients for an average 11 – 13 year Sri Lankan adolescent was calculated using mean RDA of energy, protein, and micronutrients for a 10-11 year Sri Lankan adolescent and a 12 – 15 year Sri Lankan adolescent (Medical Research Institute, 2007).

Inadequacy of energy, protein, and micronutrient intake

The number of subjects whose energy, protein, and micronutrient intake below the RDA for an average 11 – 13 year Sri Lankan adolescent was calculated and presented as a percentage value.

Statistical analysis

The mean (± SD) value of adolescents' daily energy, protein, and micronutrient intake was calculated and compared for gender difference by Two-sample t-test. The gender difference in subjects' socio-demographic characteristics was analyzed using the Chi-squared test. All the statistical analyses were performed using statistical software, SPSS version 21 statistical package.

3. Results and discussions

3.1. Socio-demographic characteristics

The study cohort comprised 336 boys (55.4%) and 270 girls (44.6%); the socio-demographic characteristics of the subjects are summarized in Table 1.

When considering the gender difference, the majority of boys were Sinhalese (35.48%); in contrast, the majority of girls were Muslims (29.0%). The majority of boys and girls had 5-8 members in the household (boys – 26.82%; girls – 29.17%), monthly household income between LKR 25 000 to 50 000 (boys – 13.95%; girls

Table 1: Gender differences in socio-demographic characteristics of the subjects

Characteristics of the subject	**Boys** %	**Girls** %
Ethnicity[1] (n=513)		
Sinhalese	35.48	19.88
Tamil	10.33	4.68
Muslim	3.51	29.0
Burger	0.20	0.19
Other	0.00	0.19
Household size[1] (n=384)		
Below 5	23.44	13.54
Between 5 - 8	26.82	29.17
Above 8	1.30	5.73
Household monthly income[1] (n=387)		
Below LKR 25 000	10.08	16.02
Between LKR 25 000 – 50 000	13.95	18.35
Between LKR 50 001 – 75 000	10.85	6.46
Between LKR 75 0001 – 100 000	8.01	4.91
Above LKR 100 000	9.56	1.81
Household living area[1] (n=281)		
Below 126.46m^2	20.28	30.25
Between 126.46 m^2 - 252.90 m^2	14.59	11.39
Above 252.90 m^2	17.08	6.41
Maternal occupation[1] (n=390)		
No occupation	31.79	36.41
Labourer	0.51	1.79
Self-employment	1.79	2.82
Non-Executive	11.79	5.13
Executive	5.38	1.28
Abroad	0.51	0.77
Maternal level of education[1] (n=388)		
No schooling	1.03	0.77
Grade 1 - 5	1.29	4.64
Grade 5 – 10	5.93	14.69
Ordinary level (O/L)	9.28	13.14
Advanced level (A/L)	19.33	9.54
Diploma / Degree	15.21	5.15
Paternal occupation[1] (n=361)		
No occupation	1.66	2.49
Labourer	5.54	9.70
Self-employment	19.11	19.67
Non-Executive	8.31	8.59
Executive	17.17	5.82
Abroad	0.83	1.11
Paternal level of education[1] (n=364)		
No schooling	1.37	1.92
Grade 1 - 5	1.65	2.47
Grade 5 – 10	6.04	12.91
Ordinary level (O/L)	10.44	14.56
Advanced level (A/L)	16.48	10.16
Diploma / Degree	17.03	4.94

[1]Significantly different by chi-squared test ($p < 0.05$)

– 18.35%), the household living area below 126.46 m^2 (boys – 20.28%; girls – 30.25%), mothers were housewives (boys – 31.79%; girls – 36.41%), and fathers were self-employed (boys – 19.11%; girls – 19.67%), irrespective of the gender. Most mothers of boys had an education level of Advanced Level (A/L), while the majority of mothers of girls had educated up to grade 5-10. In contrast, the majority of boys' fathers had an education level up to a diploma/degree, but the majority of fathers of girls had educated up to Ordinary Level (O/L).

Table 2: Mean daily intake of energy, protein, and micronutrients by adolescents aged 11-13 years in the city of Colombo (based on gender)

Nutrient	**Boys**		**Girls**	
	Mean daily intake	**RDA***	**Mean daily intake**	**RDA***
Energy (kcal)	1698.43 ± 425.02	2562.5	1645.49 ± 551.27	2250
Protein (g)**	52.05 ± 14.18	43.1	48.44 ± 20.05	43.35
Calcium (mg)	523.5 ± 220.51	1000	495.68 ± 258.79	1000
Iron (mg)	11.87 ± 4.42	26.5	11.69 ± 6.57	29
Zinc (mg)	5.88 ± 1.74	9	4.94 ± 2.02	7
Selenium (µg)**	40.90 ± 22.29	32	38.13 ± 32.41	26
Magnesium (mg)	187.77 ± 66.23	230	150.07 ± 66.48	220
Iodine (µg)	49.08 ± 28.87	120	37.72 ± 34.80	125
Vitamin A (µg)	482.99 ± 261.36	600	460.58 ± 376.96	600
Thiamin (mg)	0.75 ± 0.31	1.2	0.80 ± 0.38	1.1
Riboflavin (mg)	0.76 ± 0.40	1.3	0.71 ± 0.38	1.0
Niacin (mg)**	17.01 ± 4.91	16	16.13 ± 7.21	16
Vitamin B_6 (mg)**	0.91 ± 0.46	1.3	1.51 ± 6.78	1.2
Vitamin B_{12} (µg)	1.46 ± 0.93	2.4	1.38 ± 3.53	2.4
Folate (µg)	210.80 ± 91.4	400	169.4 ± 90.98	400
Vitamin C (mg)	32.71 ± 24.17	40	36.04 ± 35.56	40

*Mean RDA for a 10-11 year and a 12 – 15 year Sri Lankan adolescent (Medical Research Institute, 2007)
**Means were significantly different by two-sample t-test ($p < 0.05$)

3.2. Mean energy, protein, and micronutrient intake

A total of 632 food records were analyzed, and the mean daily intake of energy, protein, and micronutrients by the study cohort compared to Recommended Dietary Allowance (RDA) is summarized in Table 2.

The mean daily energy intake of the study cohort was below the recommended dietary allowance of 11- 13 year adolescents, irrespective of gender. There was no significant difference between boys' and girls' mean daily energy consumption ($p > 0.05$). In contrast, the mean daily protein intake of the adolescents was above the RDA value, and the daily protein consumption of boys was slightly higher (3.61g) than that of the girls ($p < 0.05$).

Even though according to Family Health Bureau (2020), the prevalence of overnutrition among early adolescents was a high and increasing trend in the city of Colombo, in the present study, the mean daily energy intake had not met the RDA value in both boys and girls. This could be due to the lower portion size of foods consumed by the 11-13 year adolescents, although intake of energy-dense fast food (fried rice, parata, and kottu) was high among this study cohort (Athauda et al., 2022). The adequate protein intake could be due to the transition from the vegetable-based diet to an animal-based diet in the city of Colombo (Weerahewa et al., 2018).

Considering the mean daily mineral intake of the adolescents, calcium, iron, zinc, magnesium, and iodine intake were below the RDA value, while selenium intake was above the RDA value in both boys and girls. Further, there was no significant difference in mean daily consumption of calcium, iron, zinc, magnesium, and iodine between boys and girls ($p > 0.05$). Moreover, boys consumed 2.77 µg higher selenium intake than girls ($p < 0.05$).

Calcium intake, only satisfying half of the RDA, is crucial since, during early adolescence, calcium is essential for accelerated bone growth and development (Hooshmand, 2019). Moreover, zinc is vital in sexual maturation, and the observed inadequate zinc intake in this group may cause adverse health outcomes (Roohani et al., 2013). The low level of consumption of meat and sea foods that are rich sources of zinc in this study group may be the cause for the low level of zinc intake (Athauda et al., 2022).

When considering the mean daily vitamin intake, the adolescents in the study cohort had not reached the RDA value of vitamin A, thiamin, riboflavin, vitamin B_{12}, folate, and vitamin C. Daily niacin intake was slightly above the RDA value in both boys and girls. Although girls had reached the RDA value of vitamin B_6, boys' mean daily vitamin B_6 intake was 0.39mg below the RDA value. Boys had 0.88mg of niacin intake higher than the niacin intake of girls; in contrast, girls had 0.6mg of higher vitamin B_6 intake than the vitamin B_6 intake of boys ($p < 0.05$).

Adolescents were facing micronutrient deficiencies (iron, vitamin A, zinc, and folate) globally, and this study found similar results (Ali et al., 2020). Further, dietary intake of iron and folate among Finnish adolescents was lower than the RDA, similar to the findings of our study (Hoppu et al., 2010). Our study findings were concordant with the HELENA study in Europe, in which intake of folate and calcium did not reach the RDA of adoles-

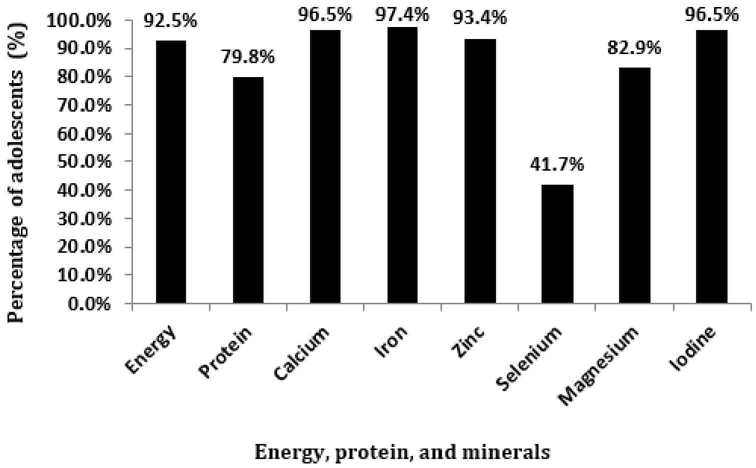

Figure 1: Percentage of adolescents aged 11-13 years inadequate in energy, protein, and mineral intake in the city of Colombo

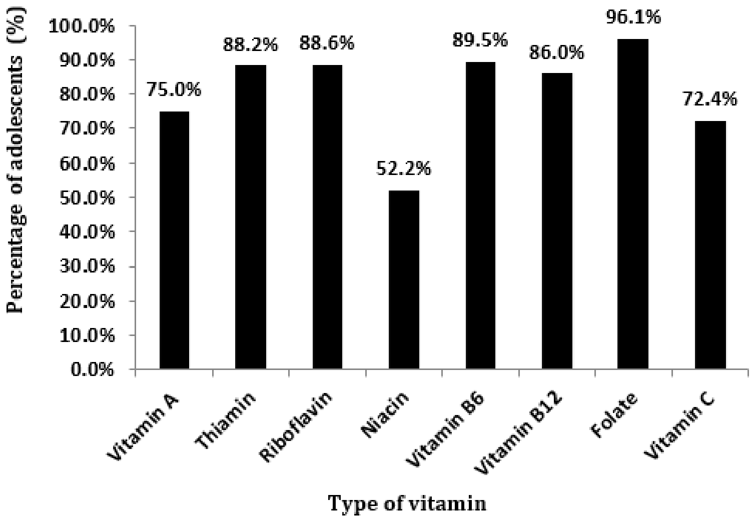

Figure 2: Percentage of adolescents aged 11-13 years inadequate in vitamin intake in the city of Colombo

cents aged between 12 and 17 years (Diethelm et al., 2014).

3.3. Inadequacy of energy, protein, and micronutrient intake

The percentage of subjects with inadequate energy and protein was 92.5% and 79.8%, respectively. Iron was the highest percentage of inadequate minerals (97.4%), while selenium was the lowest percentage (41.7%) of inadequate minerals. The percentage of adolescents with an inadequate intake of energy and minerals, i.e., calcium, iron, zinc, and iodine, was above 90%. The percentage of adolescents with inadequate energy, protein, and minerals is shown in Figure 1.

It has been revealed that the estimated population with inadequate zinc intake in Sri Lanka was 47%, the highest in the South Asian region (Harding et al., 2017). This study revealed that inadequate zinc intake among 11 – 13 years in Colombo city was 93.4%, more than twice the national value. Further, the exceptionally high inadequacy rate of iron in this study reflects that 30.5% of iron deficiency exists among secondary school children in Sri Lanka (Rodrigo et al., 2018). Comparatively low median urinary iodine concentration level among 10-14 year adolescents in the country (135 g/dl) shows inadequate intake of dietary iodine by this age group, and our study supports the findings of this study(Jayatissa et al., 2019). If early adolescents in the city of Colombo do not consume iodized salt in addition to dietary sources, they are prone to the development of goiter (American Thyroid Association, 2021).

When considering the vitamin intake of the subjects, the highest percentage of subjects were inadequate in folate (96.1%), followed by vitamin B_6 (89.5%), riboflavin (88.6%), thiamin (88.2%), vitamin B_{12} (86%), vitamin

A (75%), vitamin C (72.4%) and niacin (52.2%) (see Figure 2).

Low intake of organ meat, as well as meat and fish, which are rich sources of iron and folate, could be the cause for the very high rate of inadequacy and not meeting the RDA value of iron and folate reported among 11-13 year adolescents in the city of Colombo (Athauda et al., 2022). This study found that the consumption of dark green leafy vegetables, which are rich sources of folate by the subjects was as low as 17.7%, and thus it might have triggered the inadequacy of folate intake among the subjects (Athauda et al., 2022). The very high inadequacy rate of folate will lead to folate deficiency anemia with problems in the nervous system among early adolescents in Colombo city (Jhones Hopkins Medicine, 2021). Further, a very low percentage (29.5%) of this study cohort consumed fruits and vegetables rich in vitamin A, which showcases the reported high level of inadequacy and not meeting the RDA of vitamin A (Athauda et al., 2022).

The intake of iron had the lowest adequacy (30%). In comparison, the intake of calcium had the highest adequacy (70%), followed by vitamin A (61%), zinc (54%), and vitamin C (51%) among Indian adolescents (Rani and Rani, 2017). Adolescents in the current study had greater inadequacy rates of these micronutrients compared to Indian adolescents.

Further, studies should be conducted to determine the adequacy of micronutrient intake in preschoolers, late adolescents, and pregnant mothers, who are the most vulnerable to micronutrient deficiencies.

4. Conclusion

The early adolescents aged 11-13 years in the city of Colombo are in hidden hunger due to inadequate micronutrient intake of calcium, zinc, magnesium, iodine, vitamin A, thiamin, riboflavin, vitamin B_{12}, folate, and vitamin C. The highest percentage of adolescents with inadequate minerals and vitamins was iron and folate, respectively.

5. Data Availability

The data set generated and analyzed during the current study is available from the corresponding author upon reasonable request. As ethical clearance for the study was obtained with the terms of keeping the data set under lock and key, the data set of the current study cannot be made freely available to the public.

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