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Calcium and iron intakes of adolescents in Malaysia and their relationships with body mass index (BMI): Findings from the Adolescent Nutrition Survey 2017

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Abstract

Introduction: Adolescent health is a priority considering they represent the future generation. Data from the Adolescent Nutrition Survey 2017 were analysed to determine the prevalence of micronutrient inadequacy, particularly calcium and iron, and the relationship with body mass index (BMI) among Malaysian secondary school students. **Methods:** This cross-sectional study included students aged 13 to 17 years old studying at public and private schools. Twenty-four hours dietary recall via face-to-face interview was conducted by trained nutritionists to obtain data on dietary intake. For nutritional status, BMI-for-age *z*-score (BAZ) was analysed using WHO Anthroplus software. **Results:** From 999 respondents, 449 were boys and 550 were girls. Overall findings indicated that both boys and girls had inadequate intakes of calcium and iron in their daily diet. Mean intakes of calcium (695.7±463.2 mg/day) and iron (23.4±21.0 mg/day) were higher among boys aged 16 to 17 years old. Mean intake of iron were higher among the older age groups. Majority of the respondents (boys: 94%; girls: 97%) did not meet the recommended nutrient intake (RNI) for calcium and more than half (boys: 50%; girl: 80%) did not achieve the RNI for iron. Current findings also found significant positive but weak correlations between calcium (r=0.112, p=0.001) and iron (r=0.084, p=0.008) intakes with BMI-for-age. **Conclusion:** BMI-for-age was related to calcium and iron intakes among secondary school students in Malaysia. Thus, intervention strategies should focus on early screening and nutrition education on food choices of high calcium and high iron contents, including iron supplementation programmes, if needed.

Keywords: adolescents, calcium, iron, intake, Malaysia

INTRODUCTION

Adolescence is the transition period from childhood to adulthood with immense growth in opportunities, trials and challenges. The World Health Organization (WHO) (2014) defines an adolescent as any person between the ages of 10 and 19 years. Due to their rapid biological and psychological changes, adolescents are frequently perceived as a nutritionally vulnerable group (WHO, 2014). Adolescent health is

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to be prioritised as they are the future generation of the world and their health status is important for the well-being of each community (Patton *et al.*, 2016).

Calcium is important for bone health. Due to intensive bone and muscular development, there is an increased need for calcium among adolescents (Mouratidou *et al.*, 2013). Apart from bone and muscular development, hormonal changes and growth during puberty also encourage more mineral use, thus requiring higher intake of minerals such as calcium (Mesias *et al.*, 2013). However, most children and adolescents throughout the world are unable to meet the recommended calcium intake.

Another mineral essential for growth and development during adolescence is iron. Iron stored during growth is important for haemoglobin and blood circulation. Among boys, adequate intake of iron is necessary to sustain the rapid gain in muscle mass and blood volume. Although girls gain muscle and blood volume slower than boys, adolescent girls remain in need of high iron intake to support menstrual losses as well as for growth. Deficiency in iron among children and adolescents can lead to anaemia, which can cause impairment in physical growth, mental and motor development, as well as learning capacity (Lassi *et al.*, 2017). Iron deficiency among adolescents is recognised as a significant nutritional problem worldwide, across both developing and developed nations (Finkelstein *et al.*, 2018).

Food intake among adolescents in many developing countries nowadays comprises primarily of foods high in fat, sugar and salt content such as fast foods, processed foods, sweets and sugar-sweetened drinks. Conversely, their diet is frequently low in fibre-rich foods including whole grains, fruits and vegetables or legumes (Hassapidou *et al.*, 2006). In a past study involving 165 adolescents between 12-19 years old from a rural community in Sabah, Malaysia (Foo *et al.*, 2004), almost 98% of subjects did not meet the Malaysian Recommended Dietary Allowance (RDA) level (<9mg/day) for dietary iron intake (NCCFN, 2017). Another study in Malaysia also revealed that 80% and possibly more children achieved the Recommended Nutrient Intake (RNI) for almost all nutrients, except for calcium and vitamin D (Poh *et al.*, 2013). About 794 diet histories from adolescents aged 13 years old were analysed in The MyHEART cohort study (Majid *et al.*, 2016) in Peninsular Malaysia, which was aimed to investigate the dietary intakes of Malaysian adolescents. The study showed that both males and females consumed inadequate intakes of energy, vitamin D, and calcium. It also showed that females consumed inadequate levels of iron (<100%) (Majid *et al.*, 2016).

Healthy eating habits during adolescence are the foundation for optimum health in adulthood. Previous findings have reported an association between body weight and iron deficiency among adolescents (Hutchinson, 2016; Aigner *et al.*, 2014, Moayer *et al.*, 2006). Meanwhile, another study found no significant association between calcium and body weight management (Shapses, Heshka & Heymsfield, 2004).

Therefore, this study was undertaken to determine the prevalence of inadequate micronutrient intake, particularly calcium and iron intakes, among Malaysian adolescents, and to investigate the relationships between calcium and iron intakes with body mass index (BMI) using data from the Adolescent Nutrition Survey (ANS) (IPH, 2017).

MATERIALS AND METHODS

Study setting and sample size

The optimum sample size required for the ANS 2017 was 30,496 respondents based on the single proportion formula and stratification of the 16 states in Malaysia (including Federal Territory of Kuala Lumpur, Putrajaya, and Labuan) (IPH, 2017). Based on students' enrolment data, as well as the schools registered with the Ministry of Education Malaysia, there were 7,926 primary schools and 2,688 secondary schools were included in the sampling frame. The schools were inclusive of national schools, vernacular schools, and private schools. From this sampling frame, 311 schools were selected based on random selection to participate in ANS 2017.

Study design and participants

The Adolescent Nutrition Survey was a cross-sectional study involved adolescents aged 10 to 17 years old, attending public and private schools in Malaysia. However, only data of respondents aged 13 to 17 years old were analysed for this manuscript as this age group was more likely to have low calcium and iron consumption (IPH, 2017). Data collection commenced from 26th March to 3rd May 2017 (IPH, 2017).

Ethics approval and consent to participate

Ethical approval was obtained from the Ministry of Health, Research and Ethics Committee (NMRR No: NMRR–16–698–30042). Approval was also granted by the Ministry of Education officials at the State and District levels, as well as from the respective selected schools.

Sampling procedure

A multistage stratified cluster sampling was used to ensure a nationwide representative sample of adolescents aged 13 to 17 years old. Students were selected based on random sampling method and invited to participate in the survey. Informed consent from the students involved and parental consent was obtained before the survey was conducted. However, from the 311 qualified schools participated in this survey, only 999 respondents who completed dietary recall and sociodemographic characteristics were being analysed.

Anthropometric measurements

BMI-for-age z-scores (BAZ) of adolescents were identified based on the WHO Growth Reference 2007 (WHO, 2007). Trained research assistants conducted the anthropometric measurements. Weight and height measurements were obtained based on standard methods using a SECA weighing scale (SECA Clara 803, Germany) and a SECA stadiometer (SECA 217, Germany), recorded to the nearest 0.5 kg and 0.1 cm, respectively. The measurements were taken twice and average readings were calculated and recorded. Weight, height and age of children were processed using the WHO AnthroPlus software to calculate standard scores (z-scores) for BMI-for-age, which is an indicator for thinness.

Assessment of dietary intake

Dietary assessment in the Adolescent Nutrition Survey 2017 involved habitual food intake assessment using food frequency questionnaire and 24-hour dietary recall. However, this study only reports the outcomes from the 24-hour dietary recalls. The assessment of dietary intake was done by trained nutritionists using a single 24-hour dietary recall via face-to-face interview in the national language (Hassapidou *et al.*, 2006, Mouratidou *et al.*, 2013). Data were gathered using a standard form with the aid of food album and explorative questions to allow respondents to recall consumed foods and beverages. Nutrient intakes were determined from the diet recalls using the Nutritionist Pro software (Axxya Systems, Stafford, TX USA), based principally on the Malaysian Food Composition (Tee *et al.,* 1997). Mean intakes of calcium and iron were derived from the analysis. However, sources of calcium and iron from foods were not determined in this study, and iron intake was not differentiated between haem and non-haem iron.

Data processing and analysis
Data were analysed using SPSS version 21. Sample weight was calculated based on every student's dietary recall record and was adjusted for varying probabilities of selection, as well as for study non-responses. Complex samples analysis was performed in the statistical analysis and was conducted at 95% confidence interval. For analysis purposes, respondents were assigned according to age groups based on RNI for Malaysia 2017 (NCCFN 2017). Thus, data of calcium and iron intakes were interpreted based on these age group classifications.

RESULTS

Sociodemographic characteristics
Sociodemographic characteristics of the adolescents are shown in Table 1. Overall, 999 respondents completed data collection for dietary intake and sociodemographic characteristics. A large percentage of the respondents was from the age group of 15 to 17 years old, with slightly higher proportion of female (55.1%) students, from urban areas (53.8%), and Malays (66.6%).

Comparison of calcium and iron intakes by sex, strata and ethnicity
In Table 2, from Mann-Whitney U test and Kruskal-Wallis test, there were statistically significant differences for calcium and iron intakes

Table 1. Socio-demographic characteristics of subjects

Characteristics	*Age group*		*Total population*
	13-14 years n (%)	*15-17 years n (%)*	*n (%)*
Sex			
Boys	190 (42.3)	259 (57.7)	449 (44.9)
Girls	236 (42.9)	314 (57.1)	550 (55.1)
Strata			
Urban	223 (41.5)	314 (58.5)	537 (53.8)
Rural	203 (43.9)	259 (56.1)	462 (46.2)
Ethnicity			
Malay	291 (43.8)	374 (56.2)	665 (66.6)
Chinese	51 (36.2)	90 (63.8)	141 (14.1)
Indian	21 (48.8)	22 (51.2)	43 (4.3)
Others Bumiputeras	55 (40.4)	81 (59.6)	136 (13.6)
Others	8 (57.1)	6 (42.9)	14 (1.4)
BMI categories			
Thinness	27 (43.5)	35 (56.5)	62 (6.2)
Normal	303 (40.7)	442 (59.3)	745 (74.6)
Overweight	61 (48.6)	59 (49.2)	120 (12.0)
Obese	35 (48.6)	37 (51.4)	72 (7.2)

Table 2. Comparison of calcium and iron intakes by sex, strata and ethnic groups

Variable	*Calcium (mg)*	*Z-statistics*	*p-value*[a]	χ^2 *statistics (df)*	*p-value*[b]	*Iron (mg)*	*Z-statistics*	*p-value*[a]	χ^2 *statistics (df)*	*p-value*[b]
Sex		-5.479	<0.001***				-7.270	<0.001***		
Male	555.35					573. 45				
Female	454.81					440.04				
Strata		-2.676	0.007**				-1.651	0.099		
Urban	522.66					513.98				
Rural	473.66					483.75				
Ethnic				3.132	0.536				6.204	0.184
Malays	502.81					506.35				
Chinese	498.23					468.66				
Indian	551.30					421.47				
Other Bumiputeras	468.98					523.15				
Others	528.00					530.54				

[a]Mann-Whitney U test
[b]Kruskal-Wallis test
**p<0.01, ***p<0.001 indicate statistical significance

Table 3. Percentage of adolescents according to RNI achievements in calcium intake and iron intake

Gender	*Age group (years old)*	*Calcium n (%)*		*Iron n (%)*	
		Did not achieve RNI n (%)	*Achieved RNI n (%)*	*Did not achieve RNI n (%)*	*Achieved RNI n (%)*
Boys	13-14	183 (96.3)	7 (3.7)	85 (44.7)	105 (55.3)
	15-17	243 (93.8)	16 (6.2)	139 (53.7)	120 (46.3)
Girls	13-14	232 (98.3)	4 (1.7)	123 (52.1)	113 (47.9)
	15-17	305 (97.1)	9 (2.9)	294 (93.6)	20 (6.4)

between sex and strata. However, there was no statistically significant difference in calcium intake (χ^2=3.13, *p*=0.536) and iron intake (χ^2=6.20, *p*=0.184) between ethnic groups.

Proportion of adolescents meeting the RNI

Table 3 outlines the percentage of adolescents achieving the RNI for calcium and iron intakes in a day. Overall, most respondents did not achieve the RNI for calcium intake and more than half of them did not reach the RNI for iron intake. The results showed that 96.3% boys and 98.3% girls aged 13 to 14 years old did not achieve the RNI for calcium, respectively; while 93.8% boys and 97.1% girls aged 15 to 17 years old did not achieve the RNI for calcium. For iron intake, 44.7% boys and 53.5% girls aged 13 to 14 years old did not achieve the RNI for iron; while 52.1 % boys and 93.6% girls aged 15 to 17 years old did not achieve the RNI for iron. Besides, this study also revealed that the proportion of girls who failed to achieve the RNI for both calcium and iron intakes were higher than boys.

Correlation between calcium and iron with BMI-for-age

Although most respondents did not meet the RNI for calcium and iron intakes, this study found a significant, positive but weak correlation between calcium (*r*=0.112, *p*=0.001) and iron (*r*=0.084, *p*=0.008) intakes with BMI-for-age as presented in Table 4.

DISCUSSION

The present study highlighted the inadequacy of calcium and iron intakes among Malaysian adolescents. Despite rapid socio-economic growth, Malaysia faces the double burden of malnutrition (Ihab *et al.*, 2013), with low intakes of these two nutrients among the adolescents. Calcium need increases

Table 4. Correlations between calcium and iron intakes with BMI-for-age z-scores

Mineral	*BMI-for-age z-scores*	
	r	*p*[†]
Calcium (mg/day)	0.112	0.001
Iron (mg/day)	0.084	0.008**

[†] Pearson Correlation test

** *p*<0.01 indicates statistical significance with age due to intensive bone and muscular progress (Mesias *et al.*, 2011). It is therefore crucial to ensure sufficient calcium intake throughout the growing age to ensure optimum peak bone mass and to prevent osteoporosis in adulthood (Mouratidou *et al.*, 2013). Unfortunately, findings from the current study showed that more than 90% of adolescents did not meet the calcium RNI, thereby presenting a public health risk.

The findings from this study are consistent with earlier reports (Im *et al.*, 2014; de Assumpcao *et al.*, 2016), which revealed that most children and adolescents in Korea and in Iran failed to meet the recommended calcium intake (1300 mg/day) (WHO, 2006). Therefore, it is encouraged to provide a diet with adequate nutrient composition and sufficient calcium allowance for maximum bone mass growth (Im *et al.*, 2014).

Findings from this study also showed that adolescents consumed insufficient iron. As compared with this study, findings from of an earlier local study by Foo *et al.,* (2004) among rural communities in Sabah, Malaysia showed unsatisfactory dietary iron intake among adolescents aged 12 to 19 years, with 98% of subjects not meeting the Malaysian RDA level for iron [14.4 μmol/L (male), 10.3 μmol/L (female)]. In another local study, about 91% of female subjects had dietary iron intake below two-thirds of the RDA level compared to a smaller proportion among male adolescents (68%) (Foo *et al.*, 2004). Another finding from this current study was the lower mean calcium intake among adolescents living in the rural area, which is in line with another local study that suggested it was a common occurrence in rural areas (Foo *et al.*, 2004).

This is probably due to females having menses and not eating appropriately according to their requirements. Mesias *et al.* (2013) justified that adolescence is a period of time when iron needs are optimised in line with increases in blood volume and growth of muscle mass. Hence, lack of iron intake may lead to iron deficiency and adversely affect body physiology. Adverse effects related to iron deficiency are more likely to occur especially among female adolescents, athletes, and those who limit their meat intake (Mesias *et al.*, 2013). The current findings also showed that there were significant differences in calcium and iron intakes between boys and girls. These findings are similar with a study from China that also showed significant gender differences (Wang *et al.*, 2017).

There is a possibility of calcium absorption being interfered by high protein intake, as a previous finding mentioned that adequacy of high-quality protein intake may impact calcium absorption (Calvez *et al.,* 2012). Low bioavailability of iron might also be related to the intake of vitamin C. However, a study from the Kansas, USA mentioned most epidemiology studies were unable to show an association between vitamin C intake and iron absorption status (Cook & Reddy, 2001). Furthermore, iron deficiency anaemia is known as a significant factor contributing to micronutrient malnutrition in Malaysia (Teegarden, 2003).

This study showed a positive correlation between calcium and iron intakes with BMI -for-age *z*-score. This indicates the contribution of these minerals towards BMI. Although there is no evidence available to support the association between calcium intake and BMI, dietary calcium seems to be related to energy metabolism, where it is suggested to play a substantial role in contributing and reducing the incidence of obesity (Teegarden, 2003). However, this may be due to the effect of nutrient density, that might be influenced by total energy intake rather than the micronutrient itself. No local study has revealed any association between BMI and iron intake. Nevertheless, a foreign study which took place in a rural area in North West Ethiopia among adolescent schoolgirls, found that BMI-for-age [*AOR*=3.2; 95%CI (1.43-7.05)] was among the predictors of anaemia (Mengistu *et al.*, 2019).

Adolescents should be trained, supported and encouraged to eat healthy foods and a balanced diet, as well as to practise a healthy lifestyle to promote optimal calcium consumption and iron absorption. Findings from the current study indicate the importance of nutrition education and promotion in school environment or via school programmes to ensure that messages on balanced and healthy diet reach the adolescent group. Nutrition education and promotion on high calcium and high iron foods can enhance the knowledge and awareness on healthy nutrition practices among adolescents (Xie *et al.*, 2003).

The present study is among the few large-scale population-based studies that have been conducted in Malaysia. The data represent all students attending schools in Malaysia and the outcomes can be used to enhance health programmes, focusing particularly on nutrition, for adolescents.

Limitation of the study

This study did not encompass major food sources of calcium and iron intakes of adolescents. Besides, factors contributing to the inadequacy of calcium and iron intakes among adolescents were not determined in this study. Therefore, this information should be included in future studies to help Malaysian adolescents achieve calcium and iron recommendations.

CONCLUSION

The findings confirmed that Malaysian adolescents have inadequate calcium and iron intakes. The percentage of adolescents meeting the RNI for both calcium and iron was alarmingly high. There were significant associations between calcium and iron intakes with BMI. These results indicate that messages promoting balanced nutrition are not reaching the adolescents. The level of knowledge and awareness on good nutrition should be emphasised. Thus, intervention strategies should focus on early screening and nutrition education on food sources of high calcium and high iron contents, including iron supplementation, if needed.

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Authors' contributions

SMS, involved in collating the data, preparation of the draft manuscript, and reviewed the manuscript; RAT was responsible for the concept of the project development, prepared the draft of the manuscript, involved with interpretation of data analysis, and reviewed the manuscript; RS, principal investigator, conceptualised, responsible for the project development, supervised the project's progress, and reviewed the manuscript; RA, MP, NSAA assisted in the preparation of the manuscript, reviewed and approved the final manuscript. NIW and MAO conducted the data analysis and interpretation of the data, and reviewed the manuscript.

Availability of data and materials

Data will be available upon request from the corresponding author.

Conflict of interests

The authors declare that they have no competing interests.

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