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Energy intakes, macronutrient intakes and the percentages of energy from macronutrients with adolescent BMI: results from a 5-year cohort study in Ho Chi Minh City, Vietnam

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Abstract

Background: Adolescence is a period of life when dietary patterns and nutrient intakes may greatly influence adult fatness. This study assesses the tracking of energy and nutrient intakes of Ho Chi Minh City adolescents over 5 years. It explores the possible relationships between energy and the percentage of energy from macronutrients with BMI.

Methods: Height, weight, time spent on physical activity, screen time and dietary intakes were collected annually between 2004 and 2009 among 752 junior high school students with a mean age of 11·87 years at baseline. The tracking was investigated using correlation coefficients and weighted kappa statistics (k) for repeated measurements. Mixed effect models were used to investigate the association between energy intakes and percentage energy from macronutrients with BMI.

Results: There were increases in the mean BMI annually, but greater in boys than in girls. Correlation coefficients ($0{\cdot}2 < r < 0{\cdot}4$) between participants' intakes at baseline and 5-year follow-up suggest moderate tracking. Extended kappa values were lowest for energy from carbohydrate (CHO) in both girls and boys ($k = 0{\cdot}18$ & 0·24, respectively), and highest for protein in girls ($k = 0{\cdot}47$) and fat in boys ($k = 0{\cdot}48$). The multilevel models showed the following variables significantly correlated with BMI: CHO, fat, percentage of energy from CHO, fat, time spent for moderate to vigorous physical activity, screen time, age and sex.

Conclusions: The poor to fair tracking observed in this cohort suggests that individual dietary patterns exhibited in the first year are unlikely to predict energy and nutrient intakes in the fifth year.

Key words: Energy: Macronutrient intakes: BMI: Adolescents

The prevalence of obesity in children and adolescents in Ho Chi Minh City, Vietnam, has been increasing significantly since the early 2000s. From 2002 to 2004, the prevalence of overweight among junior high school students aged 11 to 14 years doubled from 5·0 % to 11·7 %, while obesity prevalence increased threefold from 0·8 % to 2·0 %[1]. Despite implementing health promotion programmes to prevent obesity[2,3], the prevalence of overweight and obesity in the same population of adolescents still went up to 17·8 % and 3·2 % in 2013[4]. Adolescent obesity increases the risk of adult obesity, and evidence suggests that most overweight adolescents become overweight adults[5–7]. Thus, there should be an investigation to understand and prevent overweight and obesity in adolescents and limit increases in overweight and obesity in adults in the years ahead.

Adolescence is a period of life when dietary patterns, eating behaviours and nutrient intakes may greatly influence adiposity and the risk of chronic diseases decades later[8–10]. Specifically, in a recent systematic review[8], Bruna *et al*. compiled twenty-one studies that investigated the longitudinal relationship between diet and body fat in adolescence and early adulthood. Although they found insufficient evidence on the link between diet and body fat in this population, their findings suggest that the consumption of unhealthy food or food groups (higher energy density and lower amount of nutrients) appears to be associated with a higher quantity of body fat in adolescence and early adulthood. Also, they have highlighted the need for further research on the longitudinal relationship between food consumption and body fat in this young population. Also, the macronutrient composition of

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the diet (protein and fat) may play an important role in childhood obesity[11,12]. We need to track the nutrient intakes from adolescence into young adulthood to assess the maintenance of dietary behaviours and the relative position in the rank of these behaviours over time. These routines formed in early life may influence the progression of chronic diseases later[10,13]. Interestingly, several longitudinal studies have investigated the correlation of nutrient intake from adolescence itoyoung adulthood, and the results have been inconsistent[8].

Obesity results from an imbalance in the energy balance equation[14,15], hence, the rationale for investigating the relationship between energy intake and percentage energy intake from macronutrients with adolescent adiposity. Several studies assessing these relationships showed conflicting results, yet most were cross-sectional studies[16–18]. Thus, this longitudinal study and analysis can be beneficial. This paper aims to assess the tracking of energy and macronutrient (carbohydrate (CHO), lipid and protein) intakes of adolescents in a 5-year cohort study in Ho Chi Minh City. Our specific aims are to assess the longitudinal changes and relationships between energy and percentage of energy from macronutrients with BMI in adolescents.

Methodology

Subjects

This cohort study began from a multi-stage cluster cross-sectional survey in 2004 with thirty-one selected schools, including seventeen from wealthy urban districts and fourteen from less wealthy urban districts ($n = 3319$) in Ho Chi Minh City, Vietnam. We applied systematic random sampling to select eighteen schools from these thirty-one schools as the sub-sample for the cohort study, of which eleven were from wealthy districts and seven were from less wealthy districts. Then, one class from either grade 6 or 7 was selected in each school, resulting in 784 students being invited to join the cohort study. This study is a secondary analysis, and more details of the cohort design and results are published elsewhere[19,20].

The Research Ethics Committee, Pham Ngoc Thach University of Medicine, HCMC, approved the cohort study. Participation in the study required the consent of both adolescents and their parents.

Data collection

We measured the main outcome variables (anthropometric measurements) and the exposure factors annually at each assessment round occurred at the beginning of the school year. Standing height was measured with a suspended Microtoise tape using standard methodology (precision of 0·1 cm). Body weight was measured using a Tanita BF 571 electronic scale, Tanita Corporation (precision to 0·1 kg). Information on physical activity and screen time was measured using the validated Vietnamese-Adolescent Physical Activity Recall Questionnaire (V-APARQ).[21]. A validated Youth Food Frequency Questionnaire (YFFQ).[22] was used to assess dietary intake and diet behaviours. The YFFQ included questions regarding the usual frequency of intake of 160 specific food items over the last 6 months. We used EIYOKUN v.1.[23,24], a nutrient database developed from Vietnamese food consumption tables, to calculate foods' energy, protein, CHO and fat content. Total daily nutrient intakes were then calculated by summing nutrient values for the individual foods from the frequency of consumption, the mean amount consumed and the nutrients per gram. We excluded implausible energy intakes < 500 kcal/d or > 5000 kcal/d.[25]. We calculated BMI as the weight (kg) divided by height squared (m^2).

We assessed pubertal development by a self-administered confidential questionnaire using diagrams illustrating the five Tanner stages of pubertal development[26]. Also, we asked female students the date of the first menstruation and the male students the date of attaining the adult voice. Based on the WHO definition, the pubertal stages were grouped into pre-pubescent, pubescent and post-pubescent[27].

Data analysis

We report the results as mean and standard deviation for normally distributed continuous variables. We have presented the median and interquartile ranges, because most of the nutrient distributions were right-skewed towards higher values. To test differences in the mean of energy intakes and percentage energy from macronutrients, including protein, CHO and fat, between the first and the last year, we used paired t tests, or the Wilcoxon signed rank tests when data were not normally distributed. We examined the tracking between dietary intake measured at baseline and the fifth follow-up year by computing correlation coefficients using the mixed effects model suggested by Guogen *et al.*[28]. The cut-off value of 0·2 was used to indicate tracking[29]. We also divided energy intakes and macronutrient intakes into tertiles: lowest tertile (L1), middle tertile (M1) and highest tertile (H1) and calculated the extended kappa statistics (k) for these categories based on the approach to deal with repeated measurements[30,31]. As suggested by Twisk JW et al[32] if $k > 0{\cdot}75$, the variable tracks well, if $k < 0{\cdot}40$, the variable tracks poorly, and if $0{\cdot}40 \leq k \leq 0{\cdot}7$ then there is moderate tracking for the variable.

We examined the relationship between changes (from year 1 to year 5) in total energy intakes, protein, CHO, fat intakes, percentage energy from these three macronutrients, time spent for moderate to vigorous physical activity, total screen time, sex, age and maturation with changes of BMI. Multilevel mixed effects models were used to consider the cluster effect of schools, class and within-subject correlation from repeated measurements. We conducted all analyses using Stata version 15.0 (Stata Corporation, 2018). As recommended for longitudinal data analysis[33], we used BMI instead of BMI z-score.

Results

At baseline, 759 out of 784 students (selected from the cross-sectional study) consented to participate in the cohort study. We excluded seven observations due to mean energy intakes being < 500 kcal per d or > 5000 kcal per d, yielding 752 students with dietary intake data at the baseline. After the 5-year follow-up, we excluded seventy-six students due to the over-range of

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energy intake limits. Finally, 533 students remained for analysis. A total of 143 participants were not accounted for in the analysis as they were lost to follow-up. This cohort study had a high retention rate (70·9 %). We describe the characteristics of participants at the baseline and the last year of follow-up in Table 1. There were significant differences in BMI, protein, CHO, fat, and energy intakes between boys and girls ($P < 0·001$ for BMI and $P < 0·05$ for protein, CHO, fat and energy intakes). Between year 1 and year 5, the absolute increases in BMI were significant in both sexes (20·1 kg/m^2 to 23·5 kg/m^2 for males and 18·1 kg/m^2 to 20·6 kg/m^2 for females). Boys had higher BMI values than girls ($P < 0·001$). Every year, there were increases in the mean BMI; however, the gains were greater in boys than in girls.

Table 1 also shows that boys had higher energy and nutrient intake. The median macronutrient distribution values were protein 14·7 %, CHO 50 % and fat 21·4 % of energy intake in boys in the first year, while in girls, these values were 15·0 %, 41·9 % and 22·8 %, respectively. For boys in the last year, the median macronutrient distribution values were protein 15·3 %, CHO 55·9 % and fat 23·9 %, while in girls, they were 16·4 %, 46·5 % and 24·6 %, respectively. Over the 5 years, boys and girls' energy and macronutrient intakes increased significantly ($P < 0·001$) with increasing age. There were significant differences in macronutrient intakes and percentage of energy from macronutrients between sexes at baseline and year 5, except for fat intake at baseline and percentage of energy from fat in the last year, with boys consuming more than girls.

Table 2 presents the correlation coefficients and weighted kappa values for energy, macronutrient intakes and percentage of energy from macronutrients. Generally, the correlation between energy intakes and macronutrient intakes at the individual level was poor to fair but lower for CHO intakes. The weighted kappa values are fair for energy from CHO. In most cases, the weighted kappa values are higher in boys than in girls, especially with energy from CHO (Table 2).

In Table 3 and Table 4, we separately examine the association between BMI and each macronutrient and the association between BMI and the percentage of energy from each macronutrient. While protein intake was significantly associated with BMI in univariate analysis but changed to insignificant in the multivariate model, percentage energy from protein was not significantly associated with BMI in univariate analysis, thus not included in the multivariate model. We recognised that the direction of the univariate association of BMI with CHO and the percentage of energy from CHO flipped in the multivariate model (see Table 3 and Table 4). However, the negative association between CHO and the percentage of energy from CHO with BMI in the multivariate model is small (coefficient –0·0017 for CHO or –0·8439 for the percentage of energy from CHO).

We checked for the sex differences in the multivariate models between BMI and CHO or percentage of energy from CHO and found that there was a difference between boys and girls: the association between BMI and CHO or percentage of energy from CHO was still significant for boys (the coefficient = −0·0030, with P-value = 0·013 and coefficient = −1·7544, with P-value = 0·028, respectively), but not significant for girls (the coefficient = −0·0008, with P-value = 0·245 and coefficient = −0·3838, with P-value = 0·348, respectively) *(data were not shown)*.

We also examined the association with BMI for those who were not overweight or obese at baseline and got the same results as for the analysis of the total sample.

Discussion

Among 533 adolescents from 11 to 15 years old from across Ho Chi Minh City in our sample, at the group level, we found that energy and macronutrient intakes significantly changed throughout the study from 2004 to 2009. The correlation between energy and macronutrient intakes was poor to fair at the individual level, indicating a substantial drift of subjects between the low, medium and high intake categories with increasing age. As stated, the tracking coefficient highly depends on the length of time interval[34]; the 5-year period we looked at is long enough to observe changes in eating habits and stability of food preferences. Thus, we expected a low correlation for dietary intake[35] and much lower than for biological properties such as blood markers and anthropometric indicators[36]. Furthermore, the correlation for CHO and protein was the lowest but higher for fat intake, which at least two reasons might explain. First, the teenage students were increasingly influenced by their friends' eating habits, which usually involved snacks and other fast foods (which also had a higher percentage of fat). They would switch to consuming more of these fast foods at school than homemade foods prepared by their parents (which have a more balanced nutrient content). Second, Vietnamese adolescents consume more energy from fat from 'out-of-home' foods[37], which keeps the percentage of fat intake and percentage of energy from fat higher than other macronutrient intakes. These reasons explain why fat intake increased. This increase over the 5 years was gradual, so the fat consumption data moved from one lower tertile to an adjacent higher one or stayed in the same high tertile, leading to a low correlation of nutrient intakes.

We expected that high intakes of fat and a high percentage of energy from fat would be associated with a high BMI. Findings from the present study do support this hypothesis. However, many studies worldwide have not shown a consistent relationship between energy and macronutrient intakes or the percentage of energy from macronutrients with BMI[11,17,18,38,39]. While several studies have suggested that the macronutrient composition of the diet (protein, CHO and fat) plays an important contributing role in childhood obesity[11,12,39], other studies have different findings[38,40], or even an inverse relationship[17,18]. In this study, we found a significant association between protein intake and BMI in the univariate analysis, but it became not significant in the multivariate model. A possible explanation for the lack of an association between protein intake or percentage energy from protein and BMI might be the misreporting of foods[41,42]. Our study excluded 'implausible' energy intakes from the analysis; however, this simple exclusion could not remove the effect of misreporting as this can happen in children within the included energy range but is more likely in the subgroup of children with higher BMI. When collecting data, we took two steps to minimise this bias; first, we spent a few minutes building trust and encouraging them to report as much food and

Table 1. Participants' physical characteristics as well as energy and macronutrient intakes by sex in 2004 and 2009

	Boys					Girls				
	Year 1 – 2004		Year 5 – 2009			Year 1 – 2004		Year 5 – 2009		
	n = 360		*n* = 248			*n* = 392		*n* = 285		
Normal distribution	*Mean*	SD	*Mean*	SD	P-*values†*	*Mean*	SD	*Mean*	SD	P-*values†*
Age in years	11·8	0·6	15·7	0·6		11·9	0·7	15·9	0·7	
Weight (kg)	44·6	9·6	63·6	13·4		41	7·4	56·5	10	
Height (cm)	155·7	9·7	164	8·1		153·4	8·1	159·6	7·1	
BMI (kg/m^2)	19·1	3·9	23·5	4·3	< 0·001	18·2	3·1	20·6	3·5	< 0·001
Screen time (min/week)	528·8	221·9	663·6	225·3	< 0·001	531·8	233·2	600·7	207·7	0·0001
Skew distribution	*Median*	P_{25}, P_{75}	*Median*	P_{25}, P_{75}	P-*values‡*	*Median*	P_{25}, P_{75}	*Median*	P_{25}, P_{75}	P-*values‡*
Energy (kcal)	2515·4	1933·1, 3234·8	2837·8	2299·5, 3661·6	< 0·001	2294·5	1718·0, 2904·8	2489·9	1958·5, 3063·1	< 0·001
Protein (g)	92·6	68·1, 129·3	113·0	85·3, 149·6	< 0·001	85·6	63·7, 115·8	102·4	81·1, 130·2	< 0·001
% energy from protein	14·7	13·3, 16·0	15·3	14·1, 16·4	< 0·001	15·0	13·7, 16·7	16·4	15·2, 18·1	< 0·001
CHO* (g)	311·8	218·1, 454·6	401·4	317·3, 554·8	< 0·001	229·9	178·7, 312·5	290·9	211·3, 388·5	< 0·001
% energy from CHO*	50·0	44·0, 54·8	55·9	50·5, 59·6	< 0·001	41·9	35·6, 49·6	46·5	42·7, 52·2	< 0·001
Fat (g)	61·0	39·8, 94·1	80·0	56·9, 113·8	< 0·001	56·6	39·7, 79·9	67·3	50·3, 89·2	< 0·001
% energy from fat	21·4	17·4, 27·3	23·9	21·0, 29·3	< 0·001	22·8	19·4, 27·5	24·5	21·9, 28·3	< 0·001
Time spent for MVPA** (min/week)	116·1	48·7, 364·8	63·1	37·6, 173·0	< 0·001	80·8	47·9, 182·7	37·6	17·1, 142·6	< 0·001

* CHO, Carbohydrate.
** MVPA, Moderate to Vigorous Physical Activity.
† *P*-values of paired *t* tests.
‡ *P*-values of Wilcoxon matched signed rank tests.

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Table 2. Tracking of energy and macronutrient intakes between baseline and the fifth follow-up year as estimated by correlation coefficients using a mixed effects model and weighted kappa statistics (*k*)

	Boys (n = 360)		Girls (n = 392)	
	Correlation coefficient	*95 % CI*	*Correlation coefficient*	*95 % CI*
Energy	0·49	0·41, 0·56	0·58	0·52, 0·63
Protein	0·46	0·37, 0·56	0·62	0·52, 0·71
CHO	0·50	0·41, 0·59	0·53	0·40, 0·65
Fat	0·43	0·34, 0·52	0·56	0·47, 0·67
Energy from protein	0·51	0·02, 0·98	0·37	0·18, 0·62
Energy from CHO*	0·57	0·39, 0·73	0·25	0·17, 0·35
Energy from fat	0·20	0·15, 0·27	0·34	0·26, 0·43
	Kappa value†	*95 % CI*	*Kappa value†*	*95 % CI*
Energy	0·38	0·33, 0·44	0·42	0·36, 0·47
Protein	0·40	0·33, 0·45	0·47	0·42, 0·53
CHO	0·33	0·27, 0·39	0·42	0·36, 0·47
Fat	0·41	0·36, 0·47	0·45	0·40, 0·51
Energy from protein	0·24	0·18, 0·30	0·30	0·25, 0·38
Energy from CHO*	0·24	0·18, 0·29	0·18	0·13, 0·23
Energy from fat	0·31	0·25, 0·37	0·31	0·26, 0·36

* CHO, Carbohydrate.
† Weighted kappa statistics (*k*) on tertiles of the distribution.

Table 3. Mixed effects models between total energy intake, macronutrient intakes and time spent in MVPA, sedentary time, sex and age with adolescent BMI over 5 years

BMI	Univariate Coef	95 % CI	*P*-values	Multivariate† Coef	95 % CI	*P*-values
				Multivariate Model from protein only		
Energy (kcal/d)	0·0004	0·0001, 0·0006	< 0·001	0·0062	0·0057, 0·0066	< 0·001
Protein (g/d)	0·0040	0·0009, 0·0070	0·012	–0·0010	–0·0047, 0·0026	0·586
Time spent for MVPA (min/week)**	–0·0129	–0·0181, –0·0077	< 0·001	–0·1117	–0·1192, –0·1042	< 0·001
Total screen time (min/week)	0·0053	0·0045, 0·0061	< 0·001	0·0027	0·0023, 0·0032	< 0·001
Sex = boy	2·3486	1·7585, 2·9387	< 0·001	0·8956	0·3822, 1·4090	0·001
Age	0·9483	0·7192, 1·1775	< 0·001	0·4302	0·2064, 0·6541	< 0·001
				Multivariate Model from CHO only*		
Energy (kcal/d)	0·0004	0·0001, 0·0006	< 0·001	0·0063	0·0059, 0·0068	0·001
CHO* (g/d)	0·0026	0·0015, 0·0037	< 0·001	–0·0017	–0·0027, –0·0007	0·001
Time spent for MVPA** (min/week)	–0·0129	–0·0181, –0·0077	< 0·001	–0·1114	–0·1188, –0·1041	< 0·001
Total screen time (min/week)	0·0053	0·0045, 0·0061	< 0·001	0·0028	0·0023, 0·0033	< 0·001
Sex = boy	2·3486	1·7585, 2·9387	< 0·001	1·0036	0·5159, 1·4912	< 0·001
Age	0·9483	0·7192, 1·1775	< 0·001	0·4382	0·2085, 0·6679	< 0·001
				Multivariate Model from fat only		
Energy (kcal/d)	0·0004	0·0001, 0·0006	< 0·001	0·0047	0·0042, 0·0052	< 0·001
Fat (g/d)	0·0339	0·0285, 0·0393	< 0·001	0·0268	0·0210, 0·0326	< 0·001
Time spent for MVPA** (min/week)	–0·0129	–0·0181, –0·0077	< 0·001	–0·1004	–0·1073, –0·0936	< 0·001
Total screen time (min/week)	0·0053	0·0045, 0·0061	< 0·001	0·0021	0·0016, 0·0025	< 0·001
Sex = boy	2·3486	1·7585, 2·9387	< 0·001	0·9073	0·5151, 1·2996	< 0·001
Age	0·9483	0·7192, 1·1775	< 0·001	0·3534	0·1771, 0·5297	< 0·001
Maturation	–0·2455	–0·8468, 0·3558	0·424		Not included	

* CHO, Carbohydrate.
** MVPA, Moderate to Vigorous Physical Activity.
† Multivariate data analysis using a mixed effects model includes the following variables: total energy intakes, sex, age, time spent for MVPA, total screen time and each macronutrient (protein or fat or CHO itself) with BMI.

drinks they possibly used; second, data collectors always checked if there were missing areas from the answered FFQ. However, to prevent or minimise this bias, we believe that better, or even more direct, tools intertwined in FFQ should be developed. In this study, we collected data among junior high school students exposed to unhealthy eating habits and sedentary behaviours. These students also started to have closer ties with their peers during the transition to adulthood. For them, the psychosocial importance of friendship and peer group relations increases gradually, thus intensifying the potential for peer influence[43]. Therefore, adolescents' food preferences/eating habits in Ho Chi Minh City may be less stable over time.

We noted that the direction of the univariate association of BMI with CHO and the percentage of energy from CHO has flipped in the multivariate model. A clear explanation for those negative associations is unsure. For further analysis, we also

Table 4. Mixed effects models between total energy intake, percentage energy from protein, fat and CHO and time spent in MVPA, sedentary time, sex and age with adolescent BMI over 5 years

	Univariate			Multivariate†		
BMI	Coef	95 % CI	*P*-values	Coef	95 % CI	*P*-values
				Multivariate Model for % energy from protein only		
Energy (kcal/d)	0·0004	0·0001, 0·0006	< 0·001			
% Energy from Protein	−1·1291	−5·6711, 3·4127	0·626		Not included	
Time spent for MVPA* (min/week)	−0·0129	−0·0181, −0·0077	< 0·001			
Total screen time (min/week)	0·0053	0·0045, 0·0061	< 0·001			
Sex = boy	2·3486	1·7585, 2·9387	< 0·001			
Age	0·9483	0·7192, 1·1775	< 0·001			
				Multivariate Model for % energy for CHO* only		
Energy (kcal/d)	0·0004	0·0001, 0·0006	< 0·001	0·0061	0·0057, 0·0065	< 0·001
% Energy from CHO*	1·7915	0·3788, 3·2041	0·013	−0·8439	−1·4365, −0·2513	0·005
Time spent for MVPA** (min/week)	−0·0129	−0·0181, −0·0077	< 0·001	−0·1115	−0·1190, −0·1041	< 0·001
Total screen time (min/week)	0·0053	0·0045, 0·0061	< 0·001	0·0028	0·0023, 0·0032	< 0·001
Sex = boy	2·3486	1·7585, 2·9387	< 0·001	0·9745	0. 4967, 1·4523	< 0·001
Age	0·9483	0·7192, 1·1775	< 0·001	0·4338	0·2070, 0·6606	< 0·001
				Multivariate Model for % energy for fat only		
Energy (kcal/d)	0·0004	0·0001, 0·0006	< 0·001	0·0060	0·0056, 0·0064	< 0·001
% Energy from Fat	3·0256	1·9741, 4·077	< 0·001	0·0268	0·0210, 0·0326	< 0·001
Time spent for MVPA** (min/week)	−0·0129	−0·0181, −0·0077	< 0·001	−0·1108	−0·1180, −0·1036	< 0·001
Total screen time (min/week)	0·0053	0·0045, 0·0061	< 0·001	0·0027	0·0022, 0·0031	< 0·001
Sex = boy	2·3486	1·7585, 2·9387	< 0·001	0·9019	0·4072, 1·3966	< 0·001
Age	0·9483	0·7192, 1·1775	< 0·001	0·4336	0·2040, 0·6633	< 0·001
Maturation	−0·2455	−0·8468, 0·3558	0·424		Not included	

* CHO, Carbohydrate.
** MVPA, Moderate to Vigorous Physical Activity.
† Multivariate data analysis using a mixed effects model includes the following variables: total energy intakes, sex, age, time spent for MVPA, total screen time and percentage energy from CHO/or percentage energy from fat with BMI.

found sex differences in the multivariate models between BMI and CHO or the percentage of energy from CHO. Future research should explore interactions between the level of physical activity and sex and the dietary intake of CHO.

Our study showed a significant association between BMI with time spent on physical activity and screen time. Physical activity was negatively associated with BMI, while screen time was positively associated. The decreased physical activity and increased screen time among adolescents in this study are also consistent with findings reported in the USA, Europe and several other mid-income countries[44–46]. We have published those results in several other papers[19,20]; thus, they were not this paper's focus.

The further analysis of the association of BMI of non-overweight or non-obese children at the baseline showed a significant relationship, as seen in the total sample. This analysis established that the baseline status (i.e. overweight or obese) did not influence or alter the current diet/eating behaviours in this study which is different from other reports[47].

Our study has several strengths. Firstly, the longitudinal design allowed us to study changes over time in energy and macronutrient intakes and BMI while accounting for growth and maturation. BMI typically goes up from year 1 to year 5 among students in this cohort, and we took these changes into account. Secondly, we conducted the study among junior high school students who were followed closely for at least 3–4 years until they moved to different senior schools; hence, we had little loss to follow-up in the data. The retention rate was about 70·9 % and was not differential concerning baseline characteristics. Thirdly, we used various methods to assess the correlation patterns, including correlation coefficients, percentage agreement and kappa values, which allowed for comparisons and testing of the robustness of the related findings.

The main limitation of this study is that we gathered data from 2004 to 2009. Thus the information may be less relevant today due to the rapid changes in Vietnam over the past decade. Nonetheless, a recent study[4] in 2013 showed similar patterns of overweight and obesity among adolescents in Ho Chi Minh, suggesting that our findings remain relevant. Similar reports from countries with the same economic situation as Vietnam found moderate or even poor to fair tracking in some dietary pattern scores[48,49]. The second limitation is that data collected depended on memory and perception of the usual diet, and social desirability might influence responses. Hence, the degree of memory and motivation required to complete the FFQ may change substantially year by year, thereby contributing to the poor correlations observed in this study. Furthermore, we did not collect information on psychosocial factors likely to influence the changes in adolescents' diets and BMI over time.

Despite these limitations, our findings indicate poor to moderate correlation patterns in the dietary intakes of urban adolescents over a 5-year follow-up. The poor to fair correlation observed in this cohort suggests that individual dietary patterns exhibited in the first year are unlikely to predict energy and nutrient intakes in the last year. This study also presents vital information on dietary intake and adiposity of adolescents in Ho Chi Minh City, which may prove useful in refining policies to prevent excess weight gain.

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H. K. T. participated in the design, carried out the study, performed the statistical analysis and drafted the manuscript. N-M. N. contributed to the statistical analyses and drafted the manuscript. M. J. D. participated in the design of the research and the analytical strategy and contributed to drafting the manuscript. All authors read and approved the final manuscript.

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