Original Article

doi: 10.16926/par.2026.14.07

Accelerometer-measured physical activity and sleep of adolescents in Ho Chi Minh City, Vietnam: A school-based cross-sectional study

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Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract: This study was to measure physical activity (PA) and sleep habits among junior high school students in HCMC and identify factors associated with World Health Organization (WHO) recommendations. We performed a cross-sectional study with 1,023 junior high school students were randomly selected. Participants wore wrist-worn accelerometers for seven consecutive days to objectively record PA and sleep using validated methods. Multivariate models were used to identify predictors of achieving WHO recommendations for PA (≥60 min/day moderate-to-vigorous physical activity-MVPA) and sleep (8–10 hours/night). Data completed on 948 students with 47.5% males and the mean age was 12.9 years. Only 35.1% and 42.8% met WHO PA and sleep recommendations, respectively. Boys engaged in significantly more MVPA than girls, while girls spent more time in light activity. Girls also showed better sleep quality—longer sleep duration, higher efficiency, and shorter latency—whereas older adolescents had shorter and less efficient sleep than younger peers. Across all groups, average sleep duration was below WHO recommendations. After adjusting for other factors, boys were significantly more likely than girls to achieve the PA guidelines. Overall, the findings indicate that gender, age, BMI, parental modeling, family encouragement, and supportive school environments are the strongest predictors of whether adolescents meet recommended PA levels. Girls, younger age, overweight/obesity, family sleeping reminders and quiet sleep environment were significant factors of adhering sleep recommendation. Our study revealed the multifactorial interaction of individual, family, and environmental factors in meeting WHO recommended levels for PA and sleep in adolescents. Multidisciplinary interventions are required to promote adolescent behaviors.

Keywords: Adolescents, Physical Activity, Sleep, WHO Recommendations

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Recevied: 25.08.2025; Accepted: 20.10.2025; Published online: 7.01.2026

Citation: Vinh P., Phong N., Trang N., Hong T. Accelerometer-measured physical activity and sleep of adolescents in Ho Chi Minh City, Vietnam: A school-based cross-sectional study. Phys Act Rev 2026; 14(1): 78-89. doi: 10.16926/par.2026.14.07

INTRODUCTION

During the last two decades, Vietnam is undergoing a socio-economic and nutrition transition especially in large cities. Along with the rapid economic and social changes, obesity is becoming a public health problem among many age groups including school-aged children [1]. Among children aged 5 to 19 years, the prevalence of overweight increased from 8.5% in 2010 to 19% in 2020, while obesity rose from 2.5% to 8.1% [2]. These trends are consistent with global estimates from the World Health Organization (WHO), which indicate that more than 340 million children and adolescents worldwide are overweight or obese, with the steepest increases observed in Asia. Rising obesity is associated not only with physical health risks such as hypertension, dyslipidemia, diabetes mellitus, and cardiovascular disease, but also with psychological and social consequences, such as depression, anxiety, low self-esteem, reduced concentration, and poorer academic performance [3,4].

Physical activity (PA) plays a critical role in the prevention and management of obesity. Numerous studies have shown a strong inverse association between PA levels and obesity [5]. PA also helps regulate energy balance by increasing energy expenditure and improving metabolic health, including enhanced insulin sensitivity and lipid metabolism [6]. Meanwhile, sleep is noticed as an essential part of life that makes a significant contribution to human health [7]. The process of sleeping helps the body regenerate energy to meet the demands of daily life. It was indicated that quality sleep could improve memory, learning ability, cognitive function, and adaptability to the environment [8, 9]. Physical inactivity and insufficient sleep are two modifiable risk factors strongly linked to obesity and broader health outcomes. According to WHO guidelines, children and adolescents aged 5–17 years should accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily [10], yet more than 80% of adolescents worldwide fail to meet this recommendation [11]. In Southeast Asia, levels of physical inactivity and sedentary behaviour among children and adolescents are particularly high [12]. Studies show that approximately 80% of school-aged teenagers in ASEAN (Association of Southeast Asian Nations) are inactive in their leisure time. Contributing factors include high screen use, lack of active commuting, limited physical education, and after-school education (tutoring), which together with academic pressures reduce opportunities for active play [13,14].

Sleep disorders are also increasingly prevalent: adolescents across East and Southeast Asia often report shorter sleep duration compared to their Western peers, reflecting cultural norms that prioritize academic achievement and late-night study. This chronic sleep deprivation is linked to adverse outcomes for physical health, cognition, and mental well-being [15]. Importantly, PA and sleep are not independent domains but interact in a reciprocal manner. Lack of PA has been associated with poor sleep quality, while insufficient or poor-quality sleep reduces motivation and energy for engaging in PA. Kosior-Lara and colleagues [16] demonstrated that avoidance of PA predicted higher anxiety and poorer sleep quality in women, underscoring how inactivity and disturbed sleep may reinforce one another. Particularly, among adolescents, this vicious cycle may exacerbate risks of obesity, psychological distress, and impaired school performance. Some authors reported bidirectional associations between sleep problems and anxiety, and that PA may act as a protective factor [17], or even found that anxiety and mobile phone dependence fully mediated the relation between PA and sleep disorders [18].

In Vietnam, the cultural and social context adds important challenges. Adolescents often face high academic pressure, long school hours, and additional after-school tutoring, which reduce opportunities for PA and delay bedtimes. Rapid urbanization and technological change, particularly increased screen exposure, have further contributed to sedentary lifestyles and disrupted sleep. Family expectations, parental involvement, and the home environment also strongly shape adolescents' daily routines, yet their role in influencing movement and sleep behaviors has rarely been investigated.

There are several studies investigated PA in Vietnam, especially in Ho Chi Minh City (HCMC), the largest urban center in Vietnam reporting low levels of PA among adolescents in HCMC [19,20], of whom greater time spent on small screen recreation and after-school education were proven to be associated with lower PA [21]. Some intervention activities even were trialed in schools to promote students' PA [22] but they remain limited in scope and impact. In contrast, sleep problems among Vietnamese adolescents have received little systematic attention despite being increasingly prevalent. Insufficient PA and poor sleep patterns in adolescents have been linked to obesity, mental health issues, and academic challenges [6,7]. A detailed investigation into these determinants can shed light on how these factors interact in a rapidly urbanizing environment where lifestyle changes may negatively impact adolescent health. The aim of this study was to assess and reveal the determinants of sleep and activity levels among junior high school students in HCMC, Vietnam. We hypothesised that (1) a significant proportion of adolescents do not meet WHO recommendations for physical activity and sleep; (2) individual (age, gender, BMI), family and environmental factors will be significantly associated with meeting these recommendations.

MATERIAL AND METHODS

Participants

A cross-sectional survey was conducted in a representative sample of junior high school students (aged 11-16 years) in HCMC between January and June 2022. A sample size of 485 adolescents was calculated basing the formula for a single mean, with a standard deviation of 22 minutes for daily moderate to MVPA and a margin of error (d) of 2 minutes. This estimate needs to be adjusted for the effect of clustering; i.e., for an average of 45 students per class, and an intra-class correlation of 0.048 - from the previous study[23], the design effect of 2 was taken into account. It was also reported in the previous study that approximately 10% of students may have invalid data[19], therefore the required sample size was 1,023 students. That equated to approximately 12 schools, and in each school 2 classes were examined. The sample was chosen with a multistage cluster sampling approach. In stage 1, twelve clusters (schools) were selected from a list of 200 junior high schools using a probability proportionate to population size method. In stage 2, simple random sampling was used to select one class from each grade. When classes were chosen then all students in such classes were invited to participate in the study.

Protocol

The students had their height and weight measured, and data of age, gender, family characteristics were collected with a self-administered questionnaire. Weight was measured with shoes and heavy clothes removed using a Tanita electronic scale (Tanita BF 571, Tanita Corporation, Japan) and was recorded to the nearest 100g. Standing height was measured with a SECA 213 portable stadiometer to the nearest 0.1 cm.

Adolescents' PA and sleep were also assessed by using the ActiGraph GT9X Link (AG) (ActiGraph Inc., Florida, USA). Participants wore AG on the non-dominant wrist for seven consecutive 24-h periods. They were instructed to tighten the wrist bands as much as comfort to avoid rotation of the device around the wrist. Parents were invited to complete a questionnaire about family habits and environment factors related to PA and sleep of adolescents.

Statistical analysis

Stata Version 17 (StataCorp, 2021) and 'svy' commands were used to adjust for clustering of observations within schools. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2) and the age and sex-specific IOTF BMI cut points were used to define overweight and obesity[24].

Raw acceleration data were first filtered and processed using ActiGraph's proprietary algorithms. A valid wear period was defined as at least 10 hours per day, with a minimum of four valid days (including at least one weekend day). MVPA were classified using validated wrist-specific cut-points for activity counts per minute (cpm). For this study, we selected validated thresholds for wrist-worn accelerometers proposed by Chandler et al[25]. Moderate physical activity (MPA) was defined as activity levels between 6360 and 17544 cpm, and vigorous physical activity (VPA) as counts exceeding 17544 cpm.

Sleep was evaluated using the Sleep Analysis algorithm, which based on the method described by Sadeh et al[26]. Sleep onset was defined as the first minute of the first 10-min interval after in-bed time with < 2 activity counts in all epochs. Sleep offset was the last minute of the last 10-min period before out-of-bed time with < 2 activity counts[27]. Total sleep time (TST), sleep efficiency (SE: ratio of TST to time in bed), and sleep onset latency (SOL) were calculated. Nights with less than 4 hours of valid data were excluded from analysis.

The differences of the time spent on PA and sleep between gender, age group were compared using t-test and ANOVA or Mann-Whitney and Kruskal-Wallis test when appropriate. According to WHO 2020 guidelines on PA and sedentary behaviour, children and adolescents should do at least 60 minutes per day of MVPA, across the week [10]. For sleep time duration, recommendations also determined that eight to ten hours was considered appropriate[28]. Separate models were constructed for binary outcome variables such as achieved or not achieved WHO PA and sleep recommendations. To report the estimated prevalence ratio for the binary outcomes, we performed cluster-adjusted Poisson regression. The independent variables in these models included demographic factors (age, sex, BMI categories), lifestyle behaviors, and environmental factors. Generalised linear mixed models with a random effect for the schools to incorporate intra-cluster correlations were used to test associations between each independent variables and the binary outcome variables. Multiple regression was also applied to see the association between PA and sleep achievement with other factors. Only variable(s) that were significantly associated with the outcomes ($p < 0.05$) were retained in the final model.

Ethical clearance

The study was approved by the ethics committee for medical research of the Pham Ngoc Thach University of Medicine (PNTUM). Written consent was obtained from both the students and their parents prior to data collection.

RESULTS

Table 1 presents the anthropometric characteristics of junior high school students in Ho Chi Minh City. The mean age of the participants was 12.94 years, with boys being slightly younger than girls, although the difference was not statistically significant ($p = 0.077$). Boys were significantly taller than girls ($t=-5.17$; $p < 0.001$), whereas girls showed a slightly higher BMI ($t=4.84$, $p = 0.020$). No significant difference in body weight was observed between boys and girls. Table 2 shows the distribution of age groups, grades, BMI categories, and school location among the students. The proportions of participants by age group and school location did not differ significantly between boys and girls. However, a higher percentage of girls attended grades 8–9 ($p = 0.025$) and were classified as having normal weight, whereas boys presented higher rates of underweight and obesity ($p < 0.001$).

As described in Table 3, marked gender and age differences were observed in both PA and sleep outcomes. Overall, only about one-third of adolescents achieved the WHO recommendation of ≥60 minutes of MVPA per day. Boys accumulated significantly more vigorous, moderate, and total MVPA than girls (U = 70150, 18912, and 18702 for vigorous, moderate and MVPA, respectively; all $p < 0.001$), with effect sizes ranging from moderate (vigorous activity, d = 0.33) to large (moderate activity and MVPA, d = 0.72). In contrast, girls engaged in more light-intensity activity (U = 36520; $p < 0.001$, large effect size d = 0.58). Younger adolescents were generally more active than older peers, although gender disparities in activity were evident across all ages.

Sleep outcomes revealed a different pattern. Average total sleep time was below the WHO-recommended 9–11 hours across all groups. Girls slept slightly longer than boys (U = 88438; $p < 0.05$, small effect d = 0.18), but no meaningful difference was found for total time in bed (d = 0.05). Girls, however, showed significantly better sleep quality, with higher sleep efficiency (U = 71442; $p < 0.001$, moderate effect d = 0.31) and shorter sleep onset latency (U = 56280;$p < 0.001$, large effect d = 0.43). Age trends showed that older adolescents had shorter sleep and lower efficiency compared with younger peers. The largest gender gaps in sleep were seen at age 11 (very large effect for sleep onset latency, d = 0.84; large effect for sleep efficiency, d = 0.70). Taken together, the results indicate that gender disparities in PA are both statistically and practically substantial, with boys far more active, while girls exhibit modestly better sleep quality, especially at younger ages.

Table 1. Anthropometric characteristics of junior high school students in Ho Chi Minh City

Students' characteristics	Whole sample (n = 948)		Boys (n = 450)		Girls (n = 498)		p-value
	Mean	[95% CI*]	Mean	[95% CI*]	Mean	[95% CI*]	
Age (years)	12.94	[12.71, 13.16]	12.87	[12.60, 13.14]	12.99	[12.77, 13.21]	0.077
Height (cm)	157.04	[156.05, 158.04]	158.45	[156.87, 160.04]	155.77	[155.09, 156.44]	<0.001
Weight (kg)	49.27	[48.52, 50.03]	49.52	[48.32, 50.71]	49.06	[48.34, 49.77]	0.389
BMI (kg/m^2)	19.99	[19.77, 20.22]	19.77	[19.36, 20.17]	20.20	[19.99, 20.40]	0.020

* CI: Confidence Interval

Table 2. Distribution of age groups, grades, BMI categories, and school location among junior high school students in Ho Chi Minh City

Category	Group	Whole sample n (%)	Boys n (%)	Girls n (%)	p-value
Age group	11 yrs	224 (23.6)	112 (24.9)	112 (22.5)	0.267
	12 yrs	256 (27.0)	131 (29.1)	125 (25.1)	
	13 yrs	299 (31.5)	132 (29.3)	167 (33.5)	
	14 yrs	169 (17.8)	75 (16.7)	94 (18.9)	
Grade	6–7	461 (48.6)	236 (52.4)	225 (45.2)	0.025
	8–9	487 (51.4)	214 (47.6)	273 (54.8)	
BMI category	Underweight	73 (7.7)	38 (8.4)	35 (7.0)	<0.001
	Normal weight	719 (75.5)	320 (71.1)	399 (83.1)	
	Overweight	136 (14.4)	58 (12.9)	78 (15.7)	
	Obesity	20 (2.1)	14 (3.1)	6 (1.2)	
School location	Urban	475 (49.9)	238 (52.9)	235 (47.2)	0.080
	Rural	473 (50.1)	212 (47.1)	263 (52.8)	

Table 3. Description of physical activity and sleep time of junior high school students in Ho Chi Minh City

Students' characteristics		Total		Boys		Girls		Effect size	p-values[a]
		n	Median [IQR]	n	Median [IQR]	n	Median [IQR]		
Total PA (mins/day)	Vigorous	948	2.4 [0.0, 6.5]	450	5.2 [0.0, 9.5]	498	0.3 [0.0, 3.3]	0.33	<0.001
	Moderate	948	47.8 [29.5, 71.2]	450	66.3 [49.0, 86.2]	498	29.7 [27.9, 40.1]	0.72	<0.001
	Light	948	653.1 [612.1, 682.6]	450	621.3 [588.8, 652.0]	498	679.7 [651.4, 700.2]	0.58	<0.001
	Moderate to Vigorous	948	49.6 [31.5, 75.3]	450	72.4 [54.0, 92.8]	498	31.9 [28.9, 41.6]	0.72	<0.001
Vigorous[b]	Age 11	242	3.0 [0.0, 7.0]	123	6.2 [1.1, 10.3]	119	2.0 [0.0, 4.0]	0.35	<0.001
	Age 12	219	3.6 [0.0, 9.2]*	113	7.8 [1.8, 11.9]	106	1.8 [0.0, 5.5]	0.34	<0.001
	Age 13	328	2.0 [0.0, 5.3]*	140	4.1 [0.7, 7.8]*	188	0.3 [0.0, 3.0]*	0.32	<0.001
	Age 14	159	0.3 [0.0, 4.6]**	74	2.8 [0.0, 6.7]*	85	0.0 [0.0, 2.0]**	0.29	<0.001
Moderate[b]	Age 11	242	48.1 [30.4, 73.2]	123	63.7 [49.9, 86.0]	119	30.3 [28.3, 40.2]	0.71	<0.001
	Age 12	219	51.6 [30.8, 84.7]*	113	81.0 [53.4, 96.9]*	106	30.6 [28.3, 44.3]	0.73	<0.001
	Age 13	328	47.8 [29.2, 61.1]*	140	56.9 [48.6, 79.4]*	188	29.6 [28.0, 39.5]	0.72	<0.001
	Age 14	159	47.8 [28.4, 54.7]**	74	50.9 [47.8, 76.4]*	85	28.5 [27.5, 30.4]**	0.73	<0.001
Light[b]	Age 11	242	668.2 [625.8, 708.5]	123	634.1 [603.1, 661.7]	119	708.5 [684.1, 719.5]**	0.75	<0.001
	Age 12	219	638.7 [605.5, 665.7]**	113	617.5 [592.4, 645.7]*	106	656.6 [633.9, 679.8]**	0.44	<0.001
	Age 13	328	659.5 [616.5, 690.0]*	140	619.2 [581.4, 648.1]*	188	686.0 [664.1, 699.7]**	0.66	<0.001
	Age 14	159	638.4 [602.1, 668.6]**	74	616.8 [570.7, 646.1]*	85	661.2 [628.1, 680.0]**	0.42	<0.001
Moderate to Vigorous[b]	Age 11	242	52.5 [33.3, 78.6]	123	66.7 [54.1, 95.8]	119	33.2 [30.1, 42.4]	0.72	<0.001
	Age 12	219	57.4 [34.8, 92.8]*	113	90.9 [61.5, 106.2]*	106	34.0 [29.5, 48.5]	0.71	<0.001
	Age 13	328	47.8 [30.9, 66.6]*	140	64.8 [54.1, 82.8]*	188	31.9 [29.1, 40.5]	0.73	<0.001
	Age 14	159	47.8 [28.9, 59.5]**	74	57.1 [50.1, 85.7]*	85	29.0 [27.6, 34.0]**	0.72	<0.001
Sleep time (hours/day)	Total Sleep Time (TST)	948	7.8 [6.9, 8.7]	450	7.6 [6.8, 8.3]	498	8.0 [7.2, 8.9]	0.18	<0.001
	Total Time in Bed (TIB)	948	8.9 [8.1, 9.6]	450	8.8 [8.2, 9.5]	498	9.0 [8.1, 9.8]	0.05	0.155
	Sleep Efficiency (SE%)[@]	948	88.7 [84.2, 91.7]	450	87.1 [82.7, 89.9]	498	90.2 [86.2, 93.6]	0.31	<0.001
	Sleep Onset Latency (SOL)[&]	948	39.4 [29.9, 55.0]	450	46.3 [37.7, 60.8]	498	31.3 [18.2, 45.3]	0.43	<0.001
Total Sleep Time (TST)[b]	Age 11	242	8.6 [7.8, 9.3]	123	8.2 [7.5, 9.0]	119	8.9 [8.2, 9.6]	0.30	<0.001
	Age 12	219	7.9 [7.3, 8.5]**	113	7.9 [7.5, 8.6]	106	7.8 [6.9, 8.5]**	0.09	0.165
	Age 13	328	7.7 [7.0, 8.6]**	140	7.2 [6.6, 7.8]**	188	8.1 [7.5, 9.0]**	0.48	<0.001
	Age 14	159	6.6 [5.8, 7.4]**	74	6.8 [6.0, 7.5]**	85	6.4 [5.7, 7.4]**	0.10	0.195
Total Time in Bed (TIB)[b]	Age 11	242	9.3 [8.6, 10.0]	123	9.3 [8.7, 10.0]	119	9.3 [8.6, 10.1]	0.02	0.712
	Age 12	219	9.0 [8.3, 9.5]*	113	9.0 [8.4, 9.5]*	106	9.0 [8.2, 9.6]*	0.03	0.660
	Age 13	328	8.8 [8.2, 9.6]**	140	8.6 [7.9, 9.3]**	188	9.0 [8.3, 9.9]	0.21	<0.001
	Age 14	159	8.1[7.3, 8.9]**	74	8.4 [7.6, 8.9]**	85	7.9 [7.1, 8.8]**	0.14	0.071
Sleep Efficiency (SE%)[@b]	Age 11	242	91.5 [88.6, 95.3]	123	89.1 [85.7, 91.3]	119	95.4 [92.4, 96.9]	0.70	<0.001
	Age 12	219	88.1 [84.7, 90.5]**	113	88.7 [86.0, 90.7]	106	87.2 [83.8, 90.3]**	0.15	0.028
	Age 13	328	88.8 [84.3, 91.9]**	140	85.0 [79.9, 87.9]**	188	90.8 [88.6, 93.4]**	0.58	<0.001
	Age 14	159	83.5 [77.2, 87.2]**	74	83.7 [75.8, 87.6]**	85	83.3 [78.5, 87.0]**	0.03	0.732
Sleep Onset Latency (SOL)[&b]	Age 11	242	30.4 [6.0, 41.1]	123	40.3 [36.0, 48.0]	119	5.8 [2.9, 10.9]	0.84	<0.001
	Age 12	219	43.3 [36.0, 55.0]**	113	42.6 [35.1, 49.9]	106	44.1 [36.4,58.4]**	0.12	0.074
	Age 13	328	36.7 [24.8, 57.6]**	140	57.6 [42.8, 74.9]**	188	25.8 [20.5, 35.2]**	0.69	<0.001
	Age 14	159	54.3 [40.6, 83.0]**	74	55.4 [42.3, 94.1]**	85	53.8 [39.8, 79.9]**	0.09	0.252

[a] Mann-Whitney, [b] Kruskal-Wallis test comparing median of different age group; * p-value <0.05; ** p-value < 0.001; [@] %; [&] mins/day

Figure 1 presents the Poisson regression analysis of factors associated with meeting recommended levels of PA. Overall, 35.1% of students met the WHO recommendation of MVPA per day (data were not shown in this figure). After adjusting for other factors, boys were significantly more likely than girls to achieve the PA guidelines. Compared with 14-year-olds, younger adolescents (ages 11–13) showed lower likelihoods of meeting the recommendations. Adolescents with normal BMI were more likely to be sufficiently active than those with overweight or obesity, while underweight status showed no significant association. Family and environmental factors also played important roles. Adolescents whose parents exercised frequently and those who received encouragement from family were significantly more likely to meet PA recommendations. Access to a school-yard for exercise was also positively associated with sufficient activity. In contrast, parental occupation, residential location, and the presence of nearby parks or vacant land did not show significant associations.

Figure 2 presents the associations between individual, family, and environmental factors and meeting WHO sleep recommendations. Overall, 42.8% of adolescents achieved the WHO sleep recommendations (data were not shown in this figure). After adjusting for other factors, girls were more likely than boys to achieve sufficient sleep. Compared with 14-year-olds, younger adolescents (ages 12 and 13) were also more likely to meet sleep guidelines, while age 11 showed no significant difference. Underweight adolescents were less likely than those with overweight/obesity to achieve recommended sleep duration, whereas those with normal BMI did not differ significantly. Family and home environment factors were strongly related to sleep. Adolescents who reported receiving reminders from family to sleep on time were substantially more likely to meet sleep recommendations. By contrast, being disturbed by indoor or outdoor noise was negatively associated with sufficient sleep. Having a private bedroom, the use of alarms, bedroom lights, or air conditioners did not show significant associations with sleep outcomes.

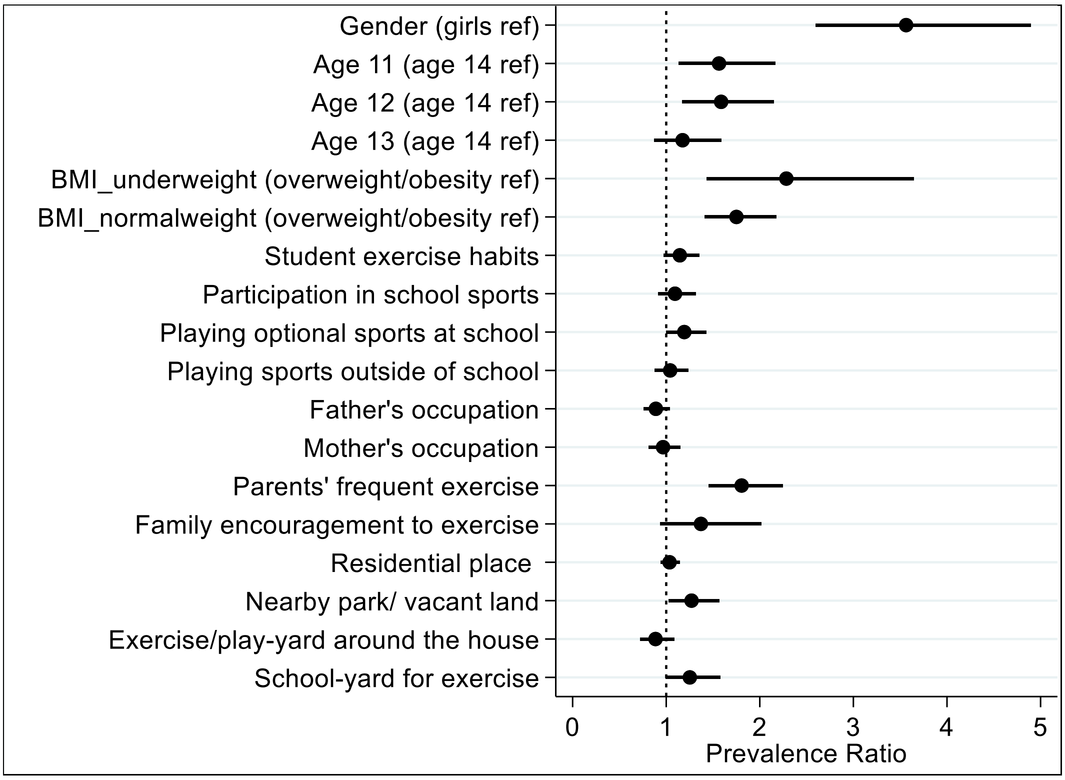

Figure 1. Forest plot of factors associated with recommended physical activity from Poisson regression

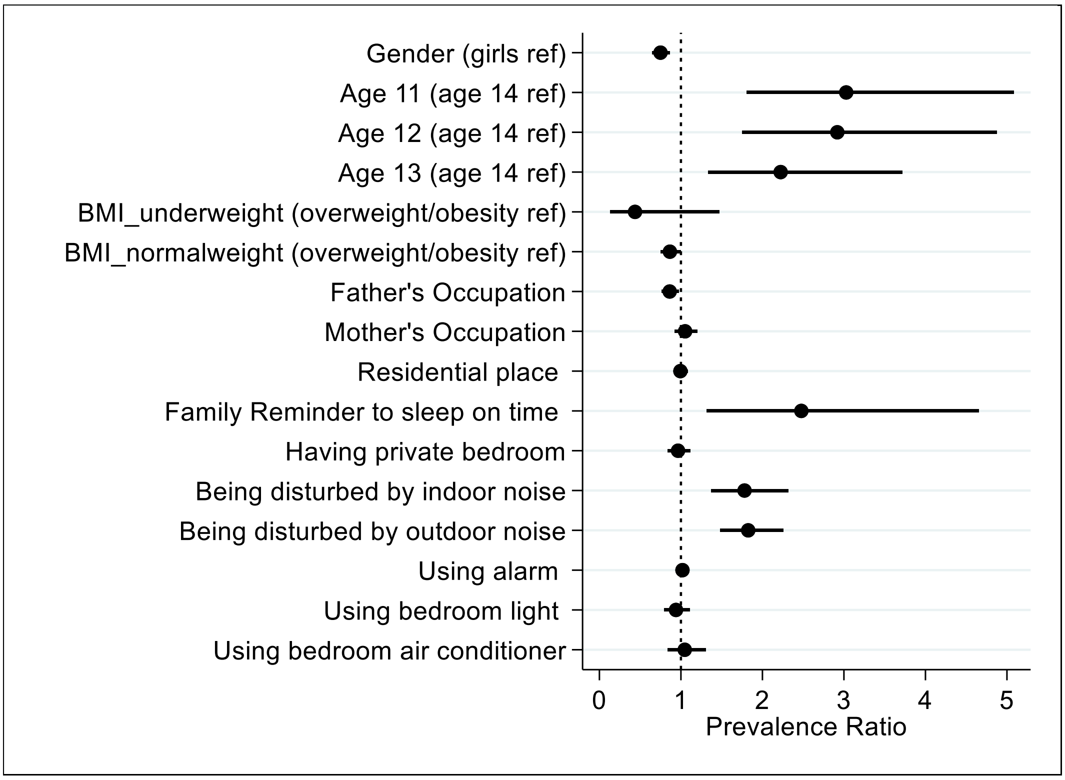

Figure 2. Forest plot of factors associated with recommended sleep time from Poisson regression

DISCUSSION

Although there have been previous studies on adolescents in HCMC, this is the first one to simultaneously assess both PA and sleep using accelerometers. We found that only 35.1% of adolescents met the WHO recommendation of 60 minutes of MVPA per day. Boys and younger adolescents engaged in more MVPA than girls and older peers, while average TST was below the WHO-recommended 9–11 hours per night. Gender, school grade, and BMI status were significantly associated with meeting WHO recommendations for both PA and sleep.

This level of PA is consistent with trends observed in Southeast Asia, where PA levels among adolescents are low due to increased sedentary lifestyles and academic demands. For example, only 26.2% of Thai adolescents and 21.4% of Malaysian adolescents met similar PA recommendations [29,30]. Gender disparities in PA participation were evident in our study, with boys more likely to meet the guidelines. Previous research attributed this to greater encouragement, more access to organized sports, and social norms that support male participation in physical activity [22]. Our findings on BMI align with research demonstrating that children with higher BMI are less likely to engage in adequate PA. A multinational study of over 6,000 children found an inverse relationship between BMI and MVPA [31]. This could be explained by the physiological limitations such as reduced mobility, alongside psychosocial challenges like body image concerns and fear of stigma which contributed to decreased activity in children with overweight or obesity [32,33]. Parental behavior also significantly influenced adolescent PA. Adolescents with physically active parents were more likely to meet PA guidelines, consistent with evidence that parental modeling promotes PA in children [34,35].

Access to parks, play-grounds and school-yards also increased the odds of meeting PA recommendations, echoing findings by Nguyen et al. which showed that access to recreational spaces reduced physical inactivity in urban Vietnamese youth [36].

Regarding sleep, our study found that average TST was insufficient, particularly among older adolescents. Girls tended to sleep longer than boys, a trend also reported in other studies and potentially explained by better sleep hygiene and emotional regulation [37]. Older students reported less sleep, which can be explained by the biological and psychosocial shifts that occur during adolescence. Girls and younger adolescents were more likely to meet WHO sleep recommendations, indicating that older adolescents face increasing academic and social demands that shorten sleep. Furthermore, our study confirmed that higher BMI had shorter sleep duration. The finding is consistent with prior evidence linking insufficient sleep to obesity (i.e., a systematic review) [38], through mechanisms such as hormonal dysregulation and appetite control. However, the observation that those with normal weight were less likely than overweight/obese peers to meet WHO sleep recommendations suggests a more complex relationship. One possible explanation is that some overweight or obese adolescents may already have adopted healthier behaviors, including sleep regulation, in attempts to control weight. This highlights the bidirectional nature of the relationship between sleep and BMI and suggests the need for longitudinal studies to disentangle causality. Importantly, these relationships must be understood in Vietnam's cultural and social context where academic expectations, late-night study, family-regulated schedules, and dense urban living (noise, shared rooms) are particularly influential here, and may affect sleep duration differently than in Western populations. These constraints mean that international comparisons should be made with caution, as culture-specific behaviors and environmental factors may moderate the strength or direction of associations between BMI and sleep.

Family and environmental influences in the present study were also significant factors. Adolescents reminded by parents to go to bed on time were more likely to meet sleep recommendations. In fact, family regulation has been found to link to better sleep quality and duration in children [39]. Similarly, a quiet sleep environment was associated with sufficient sleep, highlighting the role of environmental noise as a barrier to quality sleep [40]. Our study found that SE averaged 87.4%, higher among girls, and varied by age and BMI. This indicates that poor SE is common in adolescents and can affect academic performance and mental health [41]. Prolonged sleep latency, averaging 43.5 minutes, was more prevalent among boys and older students, likely due to screen use and inconsistent bedtime routines. These findings have some practical implications: Interventions should address not only the quantity but also the quality of PA and sleep. Programs targeting schools and families can promote structured routines, reduce noise exposure, and support positive role modeling. Public health campaigns may emphasize the importance of sleep and PA as foundations of adolescent health.

A key strength and originality of this study lies in its simultaneous assessment of both PA and sleep among Vietnamese adolescents using accelerometers. Previous studies in Vietnam have largely examined PA in isolation, with very limited attention to sleep behaviors or their interaction. Our findings therefore contribute novel evidence on the co-occurrence of insufficient activity and inadequate sleep, two interrelated behaviors that jointly shape adolescent health. Furthermore, by examining not only individual characteristics but also family and environmental influences, this study extends the literature and highlights the broader social context in which these behaviors occur. Such a multi-level perspective is particularly scarce in low- and middle-income settings, making our work an important contribution to adolescent health research in Vietnam and the wider Southeast Asian region. The other strengths of this study include the rather big sample size (n=948) allowed for subgroup analysis, and the use of WHO recommendations for PA and sleep enabled international comparisons.

Limitations of the study: The cross-sectional design prevented causal inference. Self-reported data on contextual variables might introduce bias. Environmental factors were based on perceptions rather than objective measures like GIS mapping. Family data partly based on self-assessment was a risk of declarative error. And other variables such as screen time, mental health, and dietary patterns were not included but may confound the results.

CONCLUSION

This study highlighted the complex interplay of individual, familial, and environmental factors influencing adolescents' ability to meet the WHO recommended levels for PA and sleep. These findings reinforce the need for multi-level public health interventions that encourage active family lifestyles, promote supportive sleep practices at home, and enhance access to safe recreational infrastructure. Coordinated strategies involving schools, families, and communities are needed to improve adolescent health behaviors in urban Vietnam.

Funding Statement: The study was supported by a grant from the Pham Ngoc Thach University of Medicine.

Acknowledgments: We gratefully acknowledge the support provided by school principals, class teachers, parents and students who participated in this study. We also give thanks to the staff of the Department of Epidemiology and Department of Occupational and Environmental Health, Faculty of Public Health, Pham Ngoc Thach University of Medicine, especially Mr. Vien Truong Nguyen, who provided invaluable help during data collection.

Declaration of conflicting interest

The authors declare no conflict of interest.

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