



## Multilevel factors associated with physical activity participation among Thai university students

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### ARTICLE INFO

#### Keywords:

Ecological correlates  
Health promotion  
Healthy university  
College  
Thailand

### ABSTRACT

This study investigated physical activity (PA) levels in Thai university students and their associated factors at multiple levels. Data of 3,930 university students age  $\geq 18$  years analyzed in this study were retrieved from a cross-sectional online survey, namely the ASEAN University Network – Health Promotion Network (AUN–HPN) health behavioral survey. The hierarchical generalized linear model considering clustering effects was applied to examine factors associated with sufficient PA across multiple levels. At the individual level, being female, underweight, and overweight had significantly lower odds of having sufficient PA. Sophomores had 22 % greater odds compared with freshmen. Students engaging in 1–3 and 4–6 sports activities had 3 and almost 4 times respectively higher odds of having sufficient PA. Students engaged in  $>8$  h of sedentary time, and consumed adequate amounts of fruit/vegetables had 70 % and 59 % respectively higher odds of having sufficient PA. At the environmental level, students who traveled inactively to/from university, attended a university with private recreational facilities, and a university that adopted the healthy university framework (HUF) had significantly greater odds of having sufficient PA. A majority of university students were sufficiently physically active, despite gender disparity. When promoting PA among them, focus may be targeted at females and sophomores, and consider addressing the number of sports activities engaged, fruit/vegetable consumption, availability of private university recreational facilities, and adoption of the HUF. The results support the implementation of the AUN–HPN HUF, and future initiatives within the country and the wider network for health and PA promotion.

**Abbreviations:** PA, physical activity; AUN, ASEAN University Network; HUF, healthy university framework; TUN, Thai University Network; HPN, Health Promotion Network; MET, metabolic equivalent; WEMWBS, Warwick-Edinburgh Mental Wellbeing Scales.

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<https://doi.org/10.1016/j.pmedr.2023.102510>

Received 22 June 2023; Received in revised form 11 October 2023; Accepted 8 November 2023

Available online 10 November 2023

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## 1. Introduction

Regular and sufficient participation in physical activity (PA) is crucial as it helps reduce risk of non-communicable diseases (NCD) and some chronic conditions, such as type 2 diabetes, and cardiovascular disease (Reiner et al., 2013). Although NCD are generally asymptomatic in young adults, PA has several proven benefits for them, especially for those who transition from high school to university. University students could be vulnerable to many concurrent changes in life, for instance, intellectual, emotional, social, and environmental. These changes can influence their lifestyle and, in turn, adversely affect their health (Kwan et al., 2012). PA helps university students manage their emotions better and remain resilient. To gain these benefits, the World Health Organization (WHO) recommends that people 18–64 years old should accumulate 150–300 min of moderate-intensity aerobic PA per week, 75–150 min of vigorous-intensity PA per week, or a combination of both (World Health Organization, 2020).

However, a previous study conducted in 23 low- and middle-income countries including Thailand discovered that approximately half (46 %) of university students age 18–25 years met the WHO PA guidelines. A smaller scale study conducted among Thai medical students also showed a similar proportion (49.5 %) of those who had sufficient PA (Wattanapisit et al., 2018). Based on this evidence, intervention programs need to be promoted for all university students to gain health and related benefits from PA. The information about current PA level among Thai university students from all disciplines, and factors influencing their PA participation are necessary to guide the intervention programs and advocacy. Such information, especially factors influencing Thai university student PA participation, remain largely unexplored.

PA is one of the important advocacy areas that forms an integral part of a healthy lifestyle desired by the Healthy University Framework (HUF) of the ASEAN University Network – Health Promotion Network (AUN–HPN). The AUN–HPN has more than 36 member universities across the ten ASEAN member countries (ASEAN University Network, 2023). The network has recently expanded its partners to local universities in each country, and successfully established the Thai University Network – Health Promotion Network (TUN–HPN) (ASEAN University Network, 2023). Since the launch of the TUN–HPN, there has been no published scientific evidence on PA level, patterns, nor their associated factors which could support development of PA promotion programs among Thai university students. Thus, this study investigated PA level in Thai university students and their associated factors at multiple levels based on the ecological framework. It was hypothesized that the examined variables would be associated with PA participation among Thai university students.

## 2. Methods

### 2.1. Participants and data source

Participants were Thai university students age 18 years or older currently enrolled in one of the nine Thai universities which are members of the AUN–HPN. Data of Thai university students were retrieved from a cross-sectional online survey, entitled the AUN–HPN health behavioral survey (Rahman et al., 2022a). The survey was conducted between March and June 2021 during the Thai Covid-19 epidemic. The online survey, developed based on previously-tested instruments (World Health Organization, 2005), comprised seven sections: 1) PA; 2) Social support for PA; 3) University environment; 4) Health-related behavior; 5) Mental well-being; 6) Opinions regarding university support; and 7) Sociodemographic information.

The survey was originally developed in English, and translated into the national language of participating countries. The Thai version was used for Thai university students. The survey was hosted on the Qualtrics platform (Qualtrics International Inc., WA, USA). Further details regarding development of the online AUN–HPN health behavior survey

can be found elsewhere (Rahman et al., 2022b).

### 2.2. Measurements

#### 2.2.1. Student demographic characteristics

Demographic characteristics of the students included the following: gender (male and female), age (18, 19–20, and > 20 years old), academic year (1st, 2nd, 3rd, and 4th or above), body mass index (BMI) [‘underweight’ (<18.5 kg/m<sup>2</sup>), ‘normal’ (18.5–22.9 kg/m<sup>2</sup>), ‘overweight’ (23.0–24.9 kg/m<sup>2</sup>), and ‘obese’ (≥25 kg/m<sup>2</sup>)] (World Health Organization. Regional Office for the Western Pacific, 2000), and membership of a sports club (‘yes’ / ‘no’). Grade point average (GPA) which varied by university was standardized into a 5-point GPA scale, and classified into three levels (high GPA: >3.9, moderate GPA: 3.3–3.9, and low GPA: ≤3.3).

#### 2.2.2. Student individual-level variables

*PA, exercise/sport participation, sedentary time, and sleep:* The Global Physical Activity Questionnaire version 2 (GPAQ 2.0), which had an acceptable concurrent validity ( $r = 0.54$ ) and high level of repeatability (0.67–0.81) was used to collect data on PA level (Bull et al., 2009; Keating et al., 2019). PA level were classified into ‘inactive’ (<600 metabolic equivalent (MET)-mins/week), and ‘active’ (≥600 MET-mins/week) (Chu et al., 2015). Exercise/sport participation was classified into four categories (none, 1–3, 4–6, and >6 days/week). Sedentary time was collected from the last item of GPAQ 2.0 and divided into three groups (<4, 4–8, and >8 h/day). Sleep time was dichotomized into ‘<7 h/day’ and ‘≥7 h/day’, based on recommendations on sleep hours per night for healthy adults (18–60 years) (i.e., 7 or more sleep hours/night) (Watson et al., 2015).

*Health behavior:* Students were identified as a ‘*smoker*’ or ‘*drinker*’ when they reported that they smoked or drank daily. For fruit and vegetable consumption, students were classified as ‘*healthy*’ (≥5 servings/day) or ‘*unhealthy*’ (<5 servings/day) fruit and vegetable consumers. Students who ate snacks or fast food every day were categorized into ‘*at-risk snacking*’, and otherwise were categorized as ‘*lower risk of snacking*’. Students who consumed sugary beverages every day were classified into ‘*at-risk consumption*’; and otherwise as ‘*lower risk of consumption*’. Students were classified as high salt intake (‘*yes*’), when they added salt to their food before eating ≥ 1 teaspoon/day, or otherwise were classified as low salt intake (‘*no*’) when they added < 1 teaspoon/day of salt.

*Mental well-being:* The seven-item Warwick-Edinburgh Mental Well-being Scales (WEMWBS), a previously validated and reliable tool, was used to assess mental well-being of university students (Fung, 2019). The WEMWBS score was dichotomized into negative and positive mental well-being.

*Attitude towards PA:* A previously tested questionnaire (Tabussum et al., 2017) was used to assess students’ general attitude toward PA. Students were asked how much they agreed with the five statements listed in the questionnaire. Response options ranged from 1 = ‘*Strongly disagree*’ to 5 = ‘*Strongly agree*’. Student attitudes towards PA were then dichotomized into ‘*poor*’ and ‘*good*’ based on the median of the summed score.

#### 2.2.3. Student interpersonal-level variables

The Sallis Social Support Scale, which is a valid and reliable instrument, was used to assess perceived support from family and friends (Sallis et al., 1987). There were two subscales (i.e., family and friends), and each scale consisted of 12 statements, for example, ‘(family or friend) gave me encouragement to stick with my exercise program’, and ‘(family or friend) offered to exercise with me’. A five-point Likert scale was applied with response options ranging from 1 = ‘*none*’ to 5 = ‘*very often*’ (with 6 = Did not apply).

2.2.4. Student environmental-level variables

Environmental variables included the following: housing (single house, townhouse, apartment, and high-rise condo), living arrangement (on and off campus), perceived PA of people in university (inactive and active), university aesthetic (not pleasant and pleasant), street lighting (poor and good), crime perception (unsafe and safe), trust in university (not trusted and trusted). For availability of sidewalk / bike lanes, bike racks / parking, membership-only recreational facilities, and trails / playgrounds in universities, the response options were 'unavailable' and 'available'. Students were also asked about commute time to/from university (<15 mins/15–30 mins/>30 mins), and commute type (active and inactive or by vehicle).

2.2.5. Health promotion policy

An official representative at each Thai university participating in the AUN-HPN health behavioral survey provided data at the university level. There were three questions: 1) "Does your university have written policies to promote health among students?" ('yes' / 'no' / 'being developed'), 2) The health promotion concept is a core value or incorporated into your university's values ('yes' / 'no' / 'being developed'), and 3) Has your university officially adopted the HUF of the AUN-HPN? ('yes' / 'no' / 'being considered'). 'Being developed' and 'being considered' were collapsed into 'no'.

2.3. Statistical analysis

Cases with incomplete data were removed from the dataset, leaving 3,930 cases for data analysis. Descriptive statistics were used to describe overall characteristics of Thai university students as well as presenting the contrast of students who met sufficient PA (≥600 MET/week) and those who did not (<600 MET/week) across ecological factors at different levels. The Chi-square test and binomial logistic regression were used to explore univariate associations between sufficient PA and all related factors. A hierarchical generalized linear model was then applied using a STEPwise approach to further assess the factors associated with sufficient PA across different levels. Regressions were used to account for naturally-occurring clustering in the data where the samples are nested in different Thai universities as well as gender. The final model was interpreted using the fixed effects parameters. Data analysis was conducted using RStudio v1.4.1717 (RStudio, Boston, MA, USA) and the lme4 package (Bates et al., 2011). The threshold for statistical significance was set at  $p < 0.05$ .

3. Results

Characteristics of Thai students who had sufficient PA stratified by factors at multiple levels are presented in Table 1. A majority of the Thai students who participated in the survey met the PA guidelines (71.7 %), and a large proportion were female (70.1 %). It is noteworthy that, although most participating universities reported having written PA promotion policies (93.4 %) and health promotion concepts in place (93.4 %), less than half (45.2 %) had adopted the HUF. There was a significantly higher proportion of females meeting the PA guidelines than males ( $p < 0.001$ ).

Results of univariate regression of multilevel factors associated with sufficient PA (≥600 MET/week) are presented in Table 2. Female gender ( $p < 0.001$ ), age 19–20 years old ( $p = 0.007$ ), Academic Year 2 ( $p < 0.001$ ), underweight ( $p = 0.004$ ) and overweight status ( $p < 0.001$ ), engagement in 1–3 sports ( $p = 0.001$ ) and 4–6 sports activities ( $p < 0.001$ ) per week, engagement in > 8 sedentary hours ( $p < 0.001$ ), being current alcohol drinkers ( $p < 0.001$ ), adequate fruit and vegetable consumption ( $p < 0.001$ ), good mental well-being ( $p < 0.001$ ), inactive transport to/from university ( $p < 0.001$ ), availability of membership-only recreational facility within the university ( $p = 0.006$ ), and use of a convenience store as a travel destination ( $p = 0.027$ ) were significantly associated with having sufficient PA.

Table 1

Multilevel descriptive statistics of sample characteristics by sufficiency of physical activity (PA) levels (≥600 MET/week) among Thai university students.

|   | Meeting PA guidelines |      | Total |      | $\chi^2$ test<br>p-value |
|---|-----------------------|------|-------|------|--------------------------|
|   | n                     | %    | n     | %    |                          |
| <b>Overall</b>                          | 2,819                 | 71.7 | 3,930 | 100  |                          |
| <b>Individual-level factors</b>         |                       |      |       |      |                          |
| <b>Gender</b>                           |                       |      |       |      | <0.001                   |
| Male                                    | 842                   | 29.9 | 1,064 | 27.1 |                          |
| Female                                  | 1,977                 | 70.1 | 2,866 | 72.9 |                          |
| <b>Age in years</b>                     |                       |      |       |      | 0.014                    |
| 18                                      | 1,593                 | 56.5 | 2,164 | 55.1 |                          |
| 19–20                                   | 1,098                 | 38.9 | 1,578 | 40.2 |                          |
| >20                                     | 128                   | 4.5  | 188   | 4.8  |                          |
| <b>Academic year</b>                    |                       |      |       |      | 0.002                    |
| 1st                                     | 1,553                 | 55.1 | 2,107 | 53.6 |                          |
| 2nd                                     | 727                   | 25.8 | 1,074 | 27.3 |                          |
| 3rd                                     | 416                   | 14.8 | 568   | 14.5 |                          |
| 4th or above                            | 123                   | 4.4  | 181   | 4.6  |                          |
| <b>GPA</b>                              |                       |      |       |      | 0.057                    |
| < 3.2                                   | 1,320                 | 46.8 | 1,823 | 46.4 |                          |
| 3.2–3.9                                 | 1,293                 | 45.9 | 1,839 | 46.8 |                          |
| > 3.9                                   | 206                   | 7.3  | 268   | 6.8  |                          |
| <b>BMI</b>                              |                       |      |       |      | <0.001                   |
| Underweight                             | 584                   | 20.7 | 867   | 22.1 |                          |
| Normal weight                           | 1,362                 | 48.3 | 1,873 | 47.7 |                          |
| Overweight                              | 585                   | 20.8 | 769   | 19.6 |                          |
| Obese                                   | 288                   | 10.2 | 421   | 10.7 |                          |
| <b>Member of sports club</b>            |                       |      |       |      | 0.213                    |
| Yes                                     | 2,784                 | 98.8 | 3,887 | 98.9 |                          |
| No                                      | 35                    | 1.2  | 43    | 1.1  |                          |
| <b>No. of sports engaged/week</b>       |                       |      |       |      | <0.001                   |
| None                                    | 50                    | 1.8  | 76    | 1.9  |                          |
| 1–3                                     | 308                   | 10.9 | 372   | 9.5  |                          |
| 4–6                                     | 1,412                 | 50.1 | 1,656 | 42.1 |                          |
| >6                                      | 1,049                 | 37.2 | 1,826 | 46.5 |                          |
| <b>Sedentary hours</b>                  |                       |      |       |      | <0.001                   |
| <4 h                                    | 420                   | 14.9 | 536   | 13.6 |                          |
| 4–8 h                                   | 1,218                 | 43.2 | 1,614 | 41.1 |                          |
| >8 h                                    | 1,181                 | 41.9 | 1,780 | 45.3 |                          |
| <b>Sleep hours</b>                      |                       |      |       |      | 0.122                    |
| ≤7 h                                    | 2,134                 | 75.7 | 2,948 | 75.0 |                          |
| >7 h                                    | 685                   | 24.3 | 982   | 25.0 |                          |
| <b>Smoking</b>                          |                       |      |       |      | 0.062                    |
| Smoker                                  | 307                   | 10.9 | 405   | 10.3 |                          |
| Non-smoker                              | 2,512                 | 89.1 | 3,525 | 89.7 |                          |
| <b>Alcohol drinking</b>                 |                       |      |       |      | <0.001                   |
| Drinker                                 | 2,062                 | 73.1 | 2,935 | 74.7 |                          |
| Non-drinker                             | 757                   | 26.9 | 995   | 25.3 |                          |
| <b>Fruit and vegetable consumption</b>  |                       |      |       |      | <0.001                   |
| Healthy (<5 serving/day)                | 1,727                 | 61.3 | 2,232 | 56.8 |                          |
| Unhealthy (≥5 serving/day)              | 1,092                 | 38.7 | 1,698 | 43.2 |                          |
| <b>Snacking</b>                         |                       |      |       |      | 0.238                    |
| At-risk (every day)                     | 609                   | 21.6 | 869   | 22.1 |                          |
| Lower risk (not every day)              | 2,210                 | 78.4 | 3,061 | 77.9 |                          |
| <b>High salt intake</b>                 |                       |      |       |      | 0.960                    |
| Yes                                     | 1,344                 | 47.7 | 1,872 | 47.6 |                          |
| No                                      | 1,475                 | 52.3 | 2,058 | 52.4 |                          |
| <b>High sugary beverage consumption</b> |                       |      |       |      | 0.075                    |
| Lower-risk                              | 419                   | 14.9 | 559   | 14.2 |                          |
| At risk                                 | 2,400                 | 85.1 | 3,371 | 85.8 |                          |
| <b>Mental well-being</b>                |                       |      |       |      | <0.001                   |
| Negative                                | 368                   | 13.1 | 559   | 14.2 |                          |
| Positive                                | 2,451                 | 86.9 | 3,371 | 85.8 |                          |
| <b>Attitude towards PA</b>              |                       |      |       |      | 0.844                    |
| Poor                                    | 1,610                 | 57.1 | 2,240 | 57.0 |                          |
| Good                                    | 1,209                 | 42.9 | 1,690 | 43.0 |                          |
| <b>Interpersonal-level factors</b>      |                       |      |       |      |                          |
| <b>Family PA support</b>                |                       |      |       |      | 0.802                    |
| Poor                                    | 1,564                 | 55.5 | 2,186 | 55.6 |                          |
| Good                                    | 1,255                 | 44.5 | 1,744 | 44.4 |                          |
| <b>Friends PA support</b>               |                       |      |       |      | 0.910                    |
| Poor                                    | 1,614                 | 57.3 | 2,253 | 57.3 |                          |
| Good                                    | 1,205                 | 42.7 | 1,677 | 42.7 |                          |
| <b>Environmental-level factors</b>      |                       |      |       |      |                          |

(continued on next page)

Table 1 (continued)

|  | Meeting PA guidelines |      | Total |      | $\chi^2$ test p-value |
|--|-----------------------|------|-------|------|-----------------------|
|  | n                     | %    | n     | %    |                       |
| <b>Housing</b>   |                       |      |       |      | 0.623                 |
| Single house   | 1,337                 | 47.4 | 1,859 | 47.3 |                       |
| Townhouse  | 1,304                 | 46.3 | 1,833 | 46.6 |                       |
| Apartment  | 177                   | 6.3  | 237   | 6.0  |                       |
| High-rise condo  | 1                     | 0.0  | 1     | 0.0  |                       |
| <b>Living arrangement</b>                                    |                       |      |       |      | 0.183                 |
| On campus  | 2,556                 | 90.7 | 3,579 | 91.1 |                       |
| Off campus   | 263                   | 9.3  | 351   | 8.9  |                       |
| <b>Commute time to/from university</b>                       |                       |      |       |      | 0.163                 |
| <15 min  | 1,589                 | 56.0 | 2,252 | 57.3 |                       |
| 15–30 min  | 684                   | 24.0 | 930   | 23.7 |                       |
| >30 min  | 546                   | 19.0 | 748   | 19.0 |                       |
| <b>Commute type to/from university</b>                       |                       |      |       |      | <0.001                |
| Active (walk/bike)   | 425                   | 15.1 | 534   | 13.6 |                       |
| Not active (by vehicle)                                      | 2,394                 | 84.9 | 3,396 | 86.4 |                       |
| <b>Perceived PA of people in university</b>                  |                       |      |       |      | 0.958                 |
| Inactive   | 1,542                 | 54.7 | 2,148 | 54.7 |                       |
| Active   | 1,277                 | 45.3 | 1,782 | 45.3 |                       |
| <b>University aesthetic</b>                                  |                       |      |       |      | 0.517                 |
| Not pleasant   | 774                   | 27.5 | 1,067 | 27.2 |                       |
| Pleasant   | 2,045                 | 72.5 | 2,863 | 72.8 |                       |
| <b>University street lighting</b>                            |                       |      |       |      | 0.208                 |
| Poor   | 1,695                 | 60.1 | 2,338 | 59.5 |                       |
| Good   | 1,124                 | 39.9 | 1,592 | 40.5 |                       |
| <b>Crime perception</b>                                      |                       |      |       |      | 0.551                 |
| Unsafe   | 553                   | 19.6 | 781   | 19.9 |                       |
| Safe   | 2,266                 | 80.4 | 3,149 | 80.1 |                       |
| <b>Trust in university</b>                                   |                       |      |       |      | 0.821                 |
| Not trusted  | 1,281                 | 45.4 | 1,791 | 45.6 |                       |
| Trusted  | 1,538                 | 54.6 | 2,139 | 54.4 |                       |
| <b>Availability of sidewalk/bike lanes</b>                   |                       |      |       |      | 0.082                 |
| Unavailable  | 256                   | 9.1  | 337   | 8.6  |                       |
| Available  | 2,563                 | 90.9 | 3,593 | 91.4 |                       |
| <b>Availability of bike racks/parking</b>                    |                       |      |       |      | 0.068                 |
| Unavailable  | 499                   | 17.7 | 668   | 17.0 |                       |
| Available  | 2,320                 | 82.3 | 3,262 | 83.0 |                       |
| <b>Availability of membership-only recreational facility</b> |                       |      |       |      | 0.006                 |
| Unavailable  | 491                   | 17.4 | 644   | 16.4 |                       |
| Available  | 2,328                 | 82.6 | 3,286 | 83.6 |                       |
| <b>Availability of trails/playground</b>                     |                       |      |       |      | 0.346                 |
| Unavailable  | 206                   | 7.3  | 277   | 7.0  |                       |
| Available  | 2,613                 | 92.7 | 3,653 | 93.0 |                       |
| <b>University minimarts as travel destination</b>            |                       |      |       |      | 0.031                 |
| No   | 240                   | 8.5  | 311   | 7.9  |                       |
| Yes  | 2,579                 | 91.5 | 3,619 | 92.1 |                       |
| <b>University written PA policy</b>                          |                       |      |       |      | 0.869                 |
| Unavailable  | 186                   | 6.6  | 257   | 6.5  |                       |
| Available  | 2,633                 | 93.4 | 3,673 | 93.5 |                       |
| <b>University HP concept</b>                                 |                       |      |       |      | 0.869                 |
| Unavailable  | 186                   | 6.6  | 257   | 6.5  |                       |
| Available  | 2,633                 | 93.4 | 3,673 | 93.5 |                       |
| <b>Adopted HUF</b>   |                       |      |       |      | 1.000                 |
| No   | 1,544                 | 54.8 | 2,152 | 54.8 |                       |
| Yes  | 1,275                 | 45.2 | 1,778 | 45.2 |                       |

Notes:  $\chi^2$  = Chi-square test for independence; Bold values = significance at 0.05. Abbreviations: MET = metabolic equivalent; PA = physical activity; BMI = body mass index; GPA = grade point average; HP = health promotion; HUF = Healthy University Framework.

Table 3 displays results from the hierarchical generalized linear regression analysis. In the final model (Model 3), gender, academic year of study, BMI status, number of sports engaged in per week, sedentary time, fruit and vegetable consumption, commute type to/from university, availability of membership-only recreational facility within the university, and adoption of the HUF at the host university remained strongly associated with Thai university student sufficient PA. At the individual level, when controlling for other factors, females had 13 %

Table 2

Univariable analysis of multilevel factors associated with sufficient physical activity levels ( $\geq 600$  MET/week) among Thai university students.

| Reference group ( $\geq 600$ MET/week)                    | OR   | 95 %CI |       | p-value | Sig. |
|---|------|--------|-------|---------|------|
|   |      | Lower  | Upper |         |      |
| <b>Individual-level factors</b>                           |      |        |       |         |      |
| <b>Gender (Ref: Male)</b>                                 |      |        |       |         |      |
| Female  | 1.71 | 1.44   | 2.02  | <0.001  | ***  |
| <b>Age (Ref: 18)</b>                                      |      |        |       |         |      |
| 19–20   | 0.82 | 0.71   | 0.95  | 0.007   | **   |
| >20   | 0.76 | 0.56   | 1.06  | 0.102   | n.s. |
| <b>Academic year (Ref: 1st)</b>                           |      |        |       |         |      |
| 2nd   | 1.34 | 1.14   | 1.57  | <0.001  | ***  |
| 3rd   | 1.02 | 0.83   | 1.26  | 0.823   | n.s. |
| 4th or above  | 1.32 | 0.95   | 1.82  | 0.094   |      |
| <b>GPA (Ref: &lt; 3.2)</b>                                |      |        |       |         |      |
| 3.2–3.9   | 1.11 | 0.96   | 1.28  | 0.160   | n.s. |
| > 3.9   | 0.79 | 0.58   | 1.06  | 0.126   | n.s. |
| <b>BMI (Ref: Normal weight)</b>                           |      |        |       |         |      |
| Underweight   | 0.77 | 0.65   | 0.92  | 0.004   | **   |
| Overweight  | 0.65 | 0.52   | 0.81  | <0.001  | ***  |
| Obese   | 0.95 | 0.74   | 1.22  | 0.705   | n.s. |
| <b>Member of sports club (Ref: Yes)</b>                   |      |        |       |         |      |
| No  | 0.58 | 0.25   | 1.18  | 0.162   | n.s. |
| <b>No. of sports engaged/week (Ref: &gt;6)</b>            |      |        |       |         |      |
| None  | 1.42 | 0.89   | 2.34  | 0.151   | n.s. |
| 1–3   | 3.57 | 2.70   | 4.78  | <0.001  | ***  |
| 4–6   | 4.39 | 3.64   | 5.06  | <0.001  | ***  |
| <b>Sedentary hours (Ref: &lt;4 h)</b>                     |      |        |       |         |      |
| 4–8 h   | 1.18 | 0.93   | 1.49  | 0.173   | n.s. |
| >8 h  | 1.84 | 1.47   | 2.31  | <0.001  | ***  |
| <b>Sleep hours (Ref: <math>\leq 7</math> h)</b>           |      |        |       |         |      |
| >7 h  | 1.14 | 0.97   | 1.33  | 0.113   | n.s. |
| <b>Smoking (Ref: Yes)</b>                                 |      |        |       |         |      |
| No  | 1.26 | 1.00   | 1.61  | 0.055   |      |
| <b>Alcohol drinking (Ref: No)</b>                         |      |        |       |         |      |
| Yes   | 0.74 | 0.63   | 0.88  | <0.001  | ***  |
| <b>Fruit and vegetable consumption (Ref: Unhealthy)</b>   |      |        |       |         |      |
| Healthy   | 1.90 | 1.65   | 2.18  | <0.001  | ***  |
| <b>Snacking (Ref: No)</b>                                 |      |        |       |         |      |
| Yes   | 0.90 | 0.77   | 1.07  | 0.221   | n.s. |
| <b>High salt intake (Ref: No)</b>                         |      |        |       |         |      |
| Yes   | 1.01 | 0.88   | 1.16  | 0.932   | n.s. |
| <b>High sugary beverage consumption (Ref: Lower-risk)</b> |      |        |       |         |      |
| At-risk   | 1.21 | 0.99   | 1.49  | 0.068   |      |
| <b>Mental well-being (Ref: Negative)</b>                  |      |        |       |         |      |
| Positive  | 0.72 | 0.6    | 0.88  | <0.001  | ***  |
| <b>Attitude towards PA (Ref: Poor)</b>                    |      |        |       |         |      |
| Good  | 1.02 | 0.88   | 1.17  | 0.817   | n.s. |
| <b>Interpersonal-level factors</b>                        |      |        |       |         |      |
| <b>Family PA support (Ref: Poor)</b>                      |      |        |       |         |      |
| Good  | 0.98 | 0.85   | 1.13  | 0.774   | n.s. |
| <b>Friends PA support (Ref: Poor)</b>                     |      |        |       |         |      |
| Good  | 0.99 | 0.86   | 1.14  | 0.881   | n.s. |
| <b>Environmental-level factors</b>                        |      |        |       |         |      |
| <b>Housing (Ref: Single house)</b>                        |      |        |       |         |      |
| Townhouse   | 1.04 | 0.90   | 1.20  | 0.599   | n.s. |
| Apartment   | 0.87 | 0.63   | 1.18  | 0.371   | n.s. |
| High-rise condo   | –    | –      | –     | –       | –    |
| <b>Living arrangement (Ref: on campus)</b>                |      |        |       |         |      |
| Off campus  | 0.84 | 0.65   | 1.07  | 0.164   | n.s. |
| <b>Commute time to/from university (Ref: &lt;15 mins)</b> |      |        |       |         |      |
| 15–30mins   | 0.86 | 0.73   | 1.02  | 0.090   |      |
| >30mins   | 0.89 | 0.74   | 1.07  | 0.162   | n.s. |
| <b>Commute type to/from university (Ref: Active)</b>      |      |        |       |         |      |
| Inactive  | 1.63 | 1.31   | 2.05  | <0.001  | ***  |

(continued on next page)



Table 2 (continued)

| Reference group (≥600 MET/week)   | OR   | 95 %CI |       | p-value | Sig. |
|---|------|--------|-------|---------|------|
|   |      | Lower  | Upper |         |      |
| <b>Perceived PA of people in university</b>                                     |      |        |       |         |      |
| (Ref: Inactive)   |      |        |       |         |      |
| Active  | 1.01 | 0.88   | 1.16  | 0.930   | n.s. |
| <b>University aesthetic (Ref: Not pleasant)</b>                                 |      |        |       |         |      |
| Pleasant  | 1.06 | 0.9    | 1.24  | 0.491   | n.s. |
| <b>Street lighting (Ref: Poor)</b>  |      |        |       |         |      |
| Good  | 1.10 | 0.95   | 1.26  | 0.195   | n.s. |
| <b>Crime perception (Ref: Unsafe)</b>   |      |        |       |         |      |
| Safe  | 0.95 | 0.8    | 1.12  | 0.522   | n.s. |
| <b>Trust in university (Ref: Not trusted)</b>                                   |      |        |       |         |      |
| Trusted   | 0.98 | 0.85   | 1.13  | 0.793   | n.s. |
| <b>Availability of sidewalk/bike lanes (Ref: Unavailable)</b>                   |      |        |       |         |      |
| Available   | 1.27 | 0.98   | 1.66  | 0.072   |      |
| <b>Availability of bike racks/parking (Ref: Unavailable)</b>                    |      |        |       |         |      |
| Available   | 1.2  | 0.99   | 1.45  | 0.062   |      |
| <b>Availability of membership-only recreational facility (Ref: Unavailable)</b> |      |        |       |         |      |
| Available   | 1.32 | 1.09   | 1.61  | 0.006   | **   |
| <b>Availability of trails/playground (Ref: Unavailable)</b>                     |      |        |       |         |      |
| Available   | 1.15 | 0.88   | 1.54  | 0.312   | n.s. |
| <b>University minimarts as travel destination (Ref: No)</b>                     |      |        |       |         |      |
| Yes   | 1.36 | 1.04   | 1.8   | 0.027   | *    |
| <b>University written PA policy (Ref: Unavailable)</b>                          |      |        |       |         |      |
| Available   | 1.03 | 0.78   | 1.38  | 0.813   | n.s. |
| <b>University HP concept (Ref: Unavailable)</b>                                 |      |        |       |         |      |
| Available   | 1.03 | 0.78   | 1.38  | 0.813   | n.s. |
| <b>Adopted HUF (Ref: No)</b>  |      |        |       |         |      |
| Yes   | 1.00 | 0.87   | 1.15  | 0.979   | n.s. |

\*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ .

Abbreviations: MET = metabolic equivalent; PA = physical activity; GPA = grade point average; BMI = body mass index; HP = health promotion; HUF = Healthy University Framework; n.s. = not significant.

lower odds (OR = 0.87,  $p < 0.001$ ) of having sufficient PA, compared with their male counterparts. Students in Academic Year 2 had 22 % greater odds (OR = 1.22,  $p < 0.034$ ) of having sufficient PA compared with Year 1 students. Students who were underweight and overweight had 19 % (OR = 0.81,  $p = 0.039$ ) and 26 % (OR = 0.74,  $p = 0.040$ ), respectively, lower odds of having sufficient PA, compared with those who had a normal weight. Students who engaged in 1–3 sports activities had 3 times higher odds (OR = 3.08,  $p < 0.001$ ) of having sufficient PA, compared with their peers who engaged in >6 sport activities. The odds rose to almost 4 times (OR = 3.77,  $p < 0.001$ ) when students engaged in 4–6 sport activities. Students who engaged in >8 h of sedentary behavior had 70 % higher odds (OR = 1.70,  $p < 0.001$ ) of having sufficient PA, compared to those who engaged in <4 h of sedentary behavior. Students who consumed adequate amounts of fruit and vegetables had 59 % higher odds (OR = 1.59,  $p < 0.001$ ) of having sufficient PA, compared to their peers who consumed inadequate amounts of fruit and vegetables. At the interpersonal level, no factors remained significant in the model. At the environmental level, students who traveled to/from university inactively had 70 % greater odds (OR = 1.70,  $p < 0.001$ ) of having sufficient PA, compared to those who traveled actively. Students from a university that provided private or membership-only recreational facilities within the university had 40 % greater odds (OR = 1.40,  $p = 0.009$ ) of having sufficient PA, compared to those from a university with no such

facilities. Students from a university which adopted the HUF had 24 % greater odds (OR = 1.24,  $p = 0.020$ ) of having sufficient PA, compared to those from a university which had not yet adopted the HUF.

#### 4. Discussion

Overall, a majority of Thai university students (71.7 %) had sufficient PA according to the WHO PA recommendations. Compared with previous information reported before the Covid-19 pandemic among university students from 23 low- and middle-income countries (56 % for Thailand), the prevalence discovered by the current study was much higher (Pengpid et al., 2015). In contrast, when compared with a large-scale study reporting an estimated mean of sufficient PA for adults (≥18 years old) in East and Southeast Asia (82.7 %), the prevalence identified by our study was lower (Guthold et al., 2018). Different instruments and age range of the samples included in the studies, and data collection period might have contributed to the differences in the prevalence estimates.

Noticeably, our study was conducted during the Thai Covid-19 epidemic, when social distancing, movement and gathering were enforced, and online study was the norm. These restrictions and practices are believed to have negatively affected PA engagement among university students. Nonetheless, our prevalence estimate among Thai university students is still high when compared with those of Bruneian (57.2 %), Indonesian (45.2 %), and Vietnamese (65.8 %) university students (Amornsrivatanakul et al., 2022). It is interesting to observe the relatively high prevalence of sufficient PA among Thai university students, whereas another study found a decline. This study reported a decline in the prevalence of sufficient PA among Thai young adults (18–30 years) from 72 % in 2019 (before Covid) to 58 % in 2020 (early spread) (Katewongsa et al., 2021). Despite the use of the same data collection instrument, different target samples could account for the difference in the prevalence reported. Our results were unanticipated but plausible, as the international literature suggests that university students who met the PA guidelines before the Covid generally met the guidelines during the period of lockdown (Lopez-Valenciano et al., 2020). In many cases, people engaged more in PA during major outbreaks of Covid-19, e.g. in Brazil (Sonza et al., 2021) and America (Watson et al., 2021). Thai students might engage in recreational PA at home and outdoors to keep themselves healthy, albeit with government or university restrictions during the Thai Covid epidemic (Constand et al., 2020). It is recommended that there be periodic surveys to monitor movement behavior of this specific population group to better inform PA-promotion decisions, especially among the TUN–HPN member universities.

The current study found that multiple factors at different levels seemed to influence Thai university students in achieving the PA guidelines during the Thai Covid-19 epidemic. At the individual level, gender, academic year, and BMI (among other factors) were identified as determinants by this current study. The results show that females were less physically active than their male counterparts, and this result is in line with the international literature (Irwin, 2004; Santos et al., 2016). Many reasons were cited for the gender disparity in PA participation. For example, low self-efficacy, low parental support, insecurity about body image, and cultural acceptability might lead to low PA participation among Thai females (Edwards and Sackett, 2016). To reduce the gender disparity, further research is needed to explore gender-specific factors and conditions which might influence the Thai female university student decision to be physically active.

This study also found that Thai university students who were in their second academic year were significantly more physically active than freshmen. This result is in alignment with that of ASEAN students (Amornsrivatanakul et al., 2022). The authors hypothesize that second-year students become more well-adjusted after their transition from high school to university in the first year. In terms of BMI, this study found that Thai university students who were under- or overweight were more

**Table 3**

Hierarchical generalized linear model (fixed effects) of factors related to sufficient physical activity (PA) level ( $\geq 600$  MET/week) among Thai university students.

| Variables  | Model 1:<br>Individual level |        |       |              | Model 2:<br>Individual level +<br>Interpersonal level |        |       |              | Model 3:<br>Individual level +<br>Interpersonal level +<br>Environmental level |        |       |              |
|--|------------------------------|--------|-------|--------------|---|--------|-------|--------------|--|--------|-------|--------------|
|  | OR                           | 95 %CI |       | p            | OR  | 95 %CI |       | p            | OR   | 95 %CI |       | p            |
|  |                              | Lower  | Upper |              |   | Lower  | Upper |              |  | Lower  | Upper |              |
| <i>Individual-level factors</i>                                |                              |        |       |              |   |        |       |              |  |        |       |              |
| <b>Gender</b> (Ref: Male)                                      |                              |        |       |              |   |        |       |              |  |        |       |              |
| Female   | 1.41                         | 1.18   | 1.70  | <0.001       | 1.41  | 1.18   | 1.70  | <0.001       | 0.87   | 0.71   | 0.95  | <0.001       |
| <b>Academic year</b> (Ref: 1st)                                |                              |        |       |              |   |        |       |              |  |        |       |              |
| 2nd  | 1.21                         | 1.02   | 1.44  | <b>0.043</b> | 1.21  | 1.02   | 1.44  | <b>0.043</b> | 1.22   | 1.02   | 1.46  | <b>0.034</b> |
| 3rd  | 0.98                         | 0.78   | 1.22  | 0.764        | 0.98  | 0.78   | 1.22  | 0.767        | 1.00   | 0.78   | 1.28  | 0.874        |
| 4th or above   | 1.15                         | 0.81   | 1.62  | 0.470        | 1.15  | 0.81   | 1.62  | 0.470        | 1.15   | 0.79   | 1.66  | 0.293        |
| <b>BMI</b> (Ref: Normal weight)                                |                              |        |       |              |   |        |       |              |  |        |       |              |
| Underweight  | 0.83                         | 0.69   | 1.00  | <b>0.049</b> | 0.83  | 0.69   | 1.00  | <b>0.049</b> | 0.81   | 0.67   | 0.98  | <b>0.039</b> |
| Overweight   | 0.78                         | 0.61   | 0.98  | <b>0.045</b> | 0.78  | 0.61   | 0.98  | <b>0.046</b> | 0.74   | 0.59   | 0.93  | <b>0.040</b> |
| Obese  | 0.98                         | 0.75   | 1.28  | 0.858        | 0.98  | 0.75   | 1.28  | 0.856        | 0.95   | 0.72   | 1.24  | 0.813        |
| <b>No. of sports engaged p/week</b> (Ref: >6)                  |                              |        |       |              |   |        |       |              |  |        |       |              |
| None   | 1.33                         | 0.82   | 2.22  | 0.230        | 1.33  | 0.82   | 2.22  | 0.228        | 1.36   | 0.83   | 2.26  | 0.261        |
| 1–3  | 3.01                         | 2.25   | 4.04  | <0.001       | 3.01  | 2.25   | 4.04  | <0.001       | 3.08   | 4.13   | 7.50  | <0.001       |
| 4–6  | 3.70                         | 3.13   | 4.38  | <0.001       | 3.70  | 3.13   | 4.38  | <0.001       | 3.77   | 3.18   | 4.47  | <0.001       |
| <b>Sedentary hours</b> (Ref: <4 h)                             |                              |        |       |              |   |        |       |              |  |        |       |              |
| 4–8 h  | 1.09                         | 0.85   | 1.40  | 0.479        | 1.09  | 0.85   | 1.40  | 0.479        | 1.12   | 0.88   | 1.45  | 0.512        |
| >8 h   | 1.63                         | 1.28   | 2.08  | <0.001       | 1.63  | 1.28   | 2.08  | <0.001       | 1.70   | 1.33   | 2.17  | <0.001       |
| <b>Fruit and vegetable consumption</b> (Ref: Unhealthy)        |                              |        |       |              |   |        |       |              |  |        |       |              |
| Healthy  | 1.62                         | 1.4    | 1.88  | <0.001       | 1.62  | 1.4    | 1.88  | <0.001       | 1.59   | 1.37   | 1.85  | <0.001       |
| <i>Interpersonal-level factors</i>                             |                              |        |       |              |   |        |       |              |  |        |       |              |
| <i>Environmental-level factors</i>                             |                              |        |       |              |   |        |       |              |  |        |       |              |
| <b>Commute type to/from university</b> (Ref: Active)           |                              |        |       |              |   |        |       |              |  |        |       |              |
| Inactive (by vehicle)  |                              |        |       |              |   |        |       |              | 1.70   | 1.34   | 2.17  | <0.001       |
| <b>Availability of membership-only recreational facilities</b> |                              |        |       |              |   |        |       |              |  |        |       |              |
| (Ref: Not available)   |                              |        |       |              |   |        |       |              |  |        |       |              |
| Available  |                              |        |       |              |   |        |       |              | 1.40   | 1.12   | 1.75  | <b>0.009</b> |
| <b>Adopted HUF</b> (Ref: No)                                   |                              |        |       |              |   |        |       |              |  |        |       |              |
| Yes  |                              |        |       |              |   |        |       |              | 1.24   | 1.05   | 1.44  | <b>0.020</b> |
| <b>Model fit</b>   |                              |        |       |              |   |        |       |              |  |        |       |              |
| AIC  | 4256.4                       |        |       |              | 4256.4  |        |       |              | 4228.5   |        |       |              |
| BIC  | 4359.4                       |        |       |              | 4359.4  |        |       |              | 4398.0   |        |       |              |
| Log-likelihood   | –2105.2                      |        |       |              | –2105.2   |        |       |              | –2087.3  |        |       |              |
| Pseudo-R-square (fixed effects)                                | 0.17                         |        |       |              | 0.17  |        |       |              | 0.18   |        |       |              |

Note: Bold values = Significance at 0.05.

Abbreviations: MET = metabolic equivalent; OR = odds ratio; Ref = reference group; HUF = Healthy University Framework; AIC = Akaike information criterion; BIC = Bayesian information criterion

likely to have sufficient PA, compared to those who had normal weight. Previous literature suggested a null association between BMI and PA level (Bauman et al., 2012). However, the conclusion was based on studies conducted prior to Covid-19. During the Thai Covid epidemic, students who were under- or overweight might be more concerned about their weight and health, while students who had normal weight might have less concern. Results from this study suggest that PA promotion should be promoted among all university students regardless of their weight status.

Other factors at the individual level including the number of sports engaged per week, sedentary time, and fruit and vegetable consumption were also significantly associated with sufficient PA among Thai university students. Our results show that students engaging in 6 sports or less had greater probability of having sufficient PA, compared with those who played > 6 sports. Students who engaged with too many types of sports might spend a short duration playing each sport which overall might not contribute to achieving the PA guidelines. Results of our study in terms of sedentary time were counterintuitive as this variable was positively associated with sufficient PA among Thai university students. However, these results are consistent with a previous study conducted among Thai youth (6–17 years), which reported that Thai youth were

concurrently highly engaged in both PA and sedentary behavior (Amornriwatanakul et al., 2023). A possible explanation for this phenomenon is that Thai youth might try to counterbalance prolonged periods of classroom sitting with intensive bursts of PA. International literature suggests that high PA participation and high sedentariness can co-exist without harmful effect, and participation in one behavior does not necessarily replace the other (Epstein et al., 2005). However, the underlying determinants of the results of our study remained unexplained, and further investigation for more details; e.g., type of sedentary activity that students engaged in, frequency, duration, and purpose of a given activity, is necessary. Our study also found that healthy consumption of fruit and vegetables had a positive relationship with university student sufficient PA. That finding is supported by previous literature (Pengpid et al., 2015), and suggests that these two healthy behaviors (i.e., sufficient consumption of fruit and vegetables and PA) should be simultaneously promoted among Thai university students.

At the environmental level, commute type to/from university, a university’s private or membership-only recreational facilities, and adoption of the HUF were significantly associated with university student sufficient PA. The results concerning commute type are counterintuitive, and contrast with previous evidence underlining the

significant contribution of an active commute to PA level among university students (Wilson et al., 2020). Nevertheless, that previous study collected data before the emergence of Covid-19, i.e., when there were no travel restrictions. Thus, we believe that the Covid epidemic and the containment measures of the Thai government greatly influenced our results. An active commute might have less contribution to overall PA level in a situation where physical movement and travel to/from places are restricted. Consequently, PA promotion during lockdowns or equivalent measures might need to focus heavily on other PA domains instead (e.g., study-related and recreational activities) to keep students sufficiently active. The findings of our study also suggest that private or membership-only recreational facilities within the university might induce student sufficient PA. Thai universities might consider providing membership-only recreational facilities to serve their students as an option for PA. The current study highlights the role of the HUF in encouraging student participation in PA. The HUF provides clear guidance from the policy to operational levels on promoting several health issues, including PA, and might help member universities to improve the neglected areas. Therefore, results from the current study support the initiation and distribution of the HUF, and suggest that all AUN-HPN member universities, especially in Thailand, should officially adopt the HUF.

The current study had several strengths and limitations. A major strength is the use of valid and reliable instruments for data collection. An application of the hierarchical generalized linear model incorporating ecological factors simultaneously by taking into account the effects of naturally-occurring clusters in the data is another advantage. The sample size in this study is relatively large, but might not be representative of all Thai university students across the regions and provinces. Interpretation of our study's results should be made in the context of its limitations. Recall ability and item misinterpretation are potential weaknesses of self-reported instruments. A causal relationship between the explanatory and outcome variables could not be established as our study employed a cross-sectional design. Lastly, the data were collected during the Thai Covid-19 epidemic, when disease containment measures and intensity varied in different universities. Thus, results of our study could be influenced by contextual factors specific to the study site.

## 5. Conclusions

A majority of Thai university students were sufficiently physically active, although there was a gender disparity. It might be helpful for decision-makers to address ecological factors which could be modified, including: Number of sports activities engaged in, fruit and vegetable consumption, availability of membership-only recreational facilities in the university, and adoption of the HUF. Despite potential impacts of the Covid-19 containment measures on the data collection process, the study results provide important insights and useful data that could assist in the design of future intervention research. Our results also support the implementation of the AUN-HPN HUF, which is holistic in nature, and future collaborative initiatives within the country and the wider network for health and PA promotion.

## CRedit authorship contribution statement

**Areekul Amornsriwatanakul:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. **Hanif Abdul Rahman:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. **Piyawat Katewongsa:** Conceptualization, Writing – original draft, Writing – review & editing. **Surasak Chaiyasong:** Investigation, Project administration, Writing – review & editing. **Sukanya Charoenwattana:** Investigation, Project administration, Writing – review & editing. **Supat Chupradit:**

Investigation, Project administration, Writing – review & editing. **Katiya Ivanovitch:** Investigation, Project administration, Writing – review & editing. **Yuvadee Rodjarkpai:** Investigation, Project administration, Writing – review & editing. **Krissachai Sriboonma:** Investigation, Project administration, Writing – review & editing. **Supaporn Sudnongbua:** Investigation, Project administration, Writing – review & editing. **Apichai Wattanapisit:** . **Vijj Kasemsab:** Investigation, Project administration, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

## Acknowledgments

The authors thank administrative staff of all participating universities for their assistance during sampling recruitment and data collection. We express our gratitude to all students who participated in the survey. The authors appreciate the institutional support and advice from the ASEAN University Network – Health Promotion Network International Advisory Committee, with special thanks to Dr. Wiwat Rojanapithayakorn during development of this project.

## Ethics approval and consent to participate

This study protocol was developed in accordance with relevant local and international ethical guidelines and regulations, e.g., Declaration of Helsinki. The primary ethical approval for the whole study protocol and informed online consent were obtained from the Mahidol University Central Institutional Review Board (MU-CIRB 2020/089.0704). Participating universities also obtained ethical approval from their respective institutional review boards: Naresuan University (P29936/63), Thammasat University (075/2563), Burapha University (HS035/2563), Chiang Mai University (AMSEC-63EX-019), Walailak University (WUEC-20-122-01), Mahasarakham University (266/2020), and King Mongkut's University of Technology North Bangkok used the MU-CIRB. Data analysed in this study were anonymized before use. Participants in this study gave their informed online consent by clicking 'I agree to participate' before completing the survey.

## Funding

This study was supported by the Thai Health Promotion Foundation (Children and Youth Physical Activity Studies (Grant number 61-00-1814).

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