The associations between meeting 24-hour movement guidelines and adiposity in Asian Adolescents: The Asia-Fit Study

Stanley Sai-chuen Hui1, Ru Zhang2, Koya Suzuki3, Hisashi Naito3, Govindasamy Balasekaran4, Jong Kook Song5, Soo Yeon Park6, Yiing Mei Liou7, Dajiang Lu8, Bee Koon Poh9, Kallaya Kijboonchoo10, Wiyada Thasanasuwan10

1Department of Sports Science and Physical Education, The Chinese University of Hong Kong, Hong Kong SAR, Hong Kong
2School of Physical Education & Sports Science, South China Normal University, Guangzhou, China
3Graduate School of Health and Sports Science, Juntendo University, Tokyo, Japan
4Department of Physical Education and Sports Science, Nanyang Technological University, Singapore
5School of Physical Education, Kyung Hee University, Seoul, Korea
6Department of Physical Education, Yong In University, Yongin, Korea
7Institute of Community Health Care, School of Nursing and School Health Research Center, National Yang-Ming University, Taipei, Taiwan
8School of Kinesiology, Shanghai University of Sport, Shanghai, China
9Department of Nutrition and Diabetics, The National University of Malaysia, Kuala Lumpur, Malaysia
10Department of Nutrition, Mahidol University, Bangkok, Thailand

Correspondence
Stanley Sai-chuen Hui, Department of Sports Science & Physical Education, The Chinese University of Hong Kong, Shatin, Hong Kong (hui2162@cuhk.edu.hk).

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Less is known about how compliance with 24-hour movement guidelines for physical activity (PA), sedentary behavior, and sleep affects adiposity in young people. The purposes of this study were to compare compliance with 24-hour movement guidelines in Asian adolescents and to examine the associations between compliance with 24-hour movement guidelines and body fat percentage. A sample of 12,590 adolescents aged 13.63 (± 1.01) years from eight Asian metropolitan cities including Bangkok (Thailand), Hong Kong SAR, Kuala Lumpur (Malaysia), Seoul (South Korea), Shanghai (China), Singapore, Taipei (Taiwan), and Tokyo (Japan) completed interviewer-administered questionnaires to assess moderate-to-vigorous PA, recreational screen time, sleep duration, and covariates. Body fat percentage was measured using bioelectrical impedance analysis. We found that compliance with 24-hour movement guidelines differed in Asian adolescents across the eight cities. Adjusting for covariates, there was a negative association between number of the guidelines being met and body fat percentage in Asian adolescents. In addition, meeting only the sleep guideline and both the PA and sleep guidelines had negative associations with body fat percentage compared with no guidelines being met. Our findings improve the understanding about how compliance with 24-hour movement guidelines benefit a healthy body weight in adolescents, as well as contribute to development of evidence-based 24-hour movement guidelines for Asian young people. Future research is needed to gain better insights into the directionality of the associations between compliance with 24-hour movement guidelines and adiposity, as well as the mechanisms underlying the associations in Asian adolescents.

KEYWORDS
adolescent obesity, cross-cultural comparison, movement behaviors, physical activity, sedentary behavior, sleep
Global prevalence of obesity in children and adolescents has increased from 11 million in 1975 to 124 million in 2016. The increasing trend is even more pronounced in Asia. It is well established that physically active lifestyle, reduced sedentary activities, and adequate sleep are strong protective behaviors against adolescent obesity. Recent research suggests that physical activity (PA), sedentary behavior, and sleep are codependent behaviors that exist on a movement behavior continuum over 24-hour periods. To preventing obesity and improving health status, children and adolescents aged 5 to 17 years are recommended for engaging in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) and several hours of light PA per day, spending no more than 2 hours in recreational screen time, reducing sitting for extended periods, and sleeping 9-11 hours for those aged 5-13 years and 8-10 hours for those aged 14-17 years. Previous research on compliance with 24-hour movement guidelines commonly focused on children and a combined sample of children and adolescents. Nevertheless, there are only a few studies on this topic in adolescents. A recent study found that 17.1% Canadian adolescents aged 12-17 years did not meet any of the PA, sedentary behavior, or sleep guidelines and that only 5.5% met all the three guidelines. Similar results were reported in Hong Kong and Korean adolescents. The question of compliance with 24-hour movement guidelines has not been fully examined in adolescents, and more research is needed.

Current evidence is still mixed for the associations between adiposity indicators (eg, body mass index and body fat percentage) and compliance with 24-hour movement guidelines for PA, sedentary behavior, and sleep. Some studies found that children and adolescents meeting all three guidelines had lower body mass index (BMI) compared with those meeting none of the guidelines, while others have found that combinations of the guideline met did not associate with BMI. Further research is warranted to expand the knowledge on the associations of compliance with 24-hour movement guidelines and overweight and obesity in adolescents.

Multi-country data on compliance with 24-hour movement behaviors are rare, with the exception of one study in which movement behaviors were investigated in children from 12 countries and a wide range of economic and demographic characteristics. In Asia, adolescent 24-hour movement behaviors have been investigated in Korea and Hong Kong. Despite both of the studies using nationally representative samples, the wide variety of sampling strategies and the lack of standardized and validated measurements made it difficult to evaluate inter-country differences in compliance with the 24-hour movement behaviors in adolescents across Asian megacities. Data collected in a single country or subnational region may show limited variance and results. Examining data in different cultural and economic contexts can improve the understanding of the generalizability of the results.

Therefore, the purposes of this study were to determine and compare compliance with 24-hour movement guidelines in Asian adolescents, and to examine the association between compliance with 24-hour movement guidelines and body fat percentage. We hypothesized that (a) number of the guidelines being met and combinations of the guidelines being met would differ in Asian adolescents across cities, and (b) number of the guidelines being met and combinations of the guidelines being met would be associated with body fat percentage in Asian adolescents.

## METHODS

### 2.1 Study design and participants

The Asia-Fit project was a cross-sectional study conducted in eight Asian metropolises including Bangkok (Thailand), Hong Kong SAR, Kuala Lumpur (Malaysia), Seoul (South Korea), Shanghai (China), Singapore, Taipei (Taiwan), and Tokyo (Japan). The aim of the Asia-Fit study was to investigate and compare health-related fitness, movement behaviors, and body fat percentage in Asian adolescents. These cities were selected because they (a) represent the most important metropolises in Asian countries and within-country regions, and (b) differ in terms of geography, culture, and ethnicity. A detailed description of the study design and sampling methodology can be found elsewhere. In brief, a stratified random sampling strategy was used to recruit adolescents from secondary schools in each study city. Gender, age, and geographic locations of schools were considered in the sampling process. All students aged 12-15 years with good health status enabling them to participate in physical education classes were eligible. We targeted adolescents aged 12-15 years because they were in a transition period from primary to secondary school, and were characterized by significant changes in their lifestyle behaviors such as increased recreational screen time.

The ethical committee on the Use of Human & Animal Subjects in Teaching and Research (HASC) in each city approved the Asia-Fit study. A sample of 12,590 adolescents aged 13.63 (± 1.01) years provided written consent signed by their legal guardians and participated this study during academic year 2013-2014. Data collection processes, equipment standards, test instructions, and scoring were consistent in the eight cities using the same operational procedures.
2.2 Measures

Participants completed an interviewer-administered survey to assess their MVPA, recreational screen time, sleep duration, and covariates during a physical education lesson. The test of body fat percentage was conducted under the supervision of trained research assistants. To reduce potential influence of seasonality, data collection was conducted at the same time in each city.

MVPA was measured using the interviewer-administered International Physical Activity Questionnaire-Short Form (IPAQ-SF), which has shown adequate validity in many Asian countries and regions such as China, Japan, Korea, Malaysia, and Taiwan. Participants reported the frequency (times/week) and duration (minutes/time) of walking, moderate activities, and vigorous activities in past seven days. Following the instrument of IPAQ-SF, we only considered the activities that were performed in bouts of at least 10 minutes. The frequency and duration were multiplied to calculate minutes of these three PA types per week. MVPA (minutes/week) was calculated as a sum of the minutes of moderate activities and vigorous activities.

Recreational screen time was evaluated using the Adolescent Sedentary Activity Questionnaire, which has acceptable reliability and validity in the assessment of a range of recreational screen activities among young people. Participants reported time spent on recreational screen activities such as watching TV, using the internet, and playing video games for a typical weekday and weekend. According to previous studies, recreational screen time (hours/day) was calculated as weekday screen time × 5 + weekend screen time × 2/7.

Sleep duration: Participants reported bedtime and wake-up times separately for a typical weekday and weekend. According to previous studies, sleep duration (hours/day) was calculated as weekday sleep duration × 5 + weekend sleep duration × 2/7.

According to 24-hour movement guidelines for adolescents, meeting the PA guideline was operationalized as “average daily MVPA is at least 60 minutes per day,” meeting the sedentary behavior guideline was operationalized as “no more than 2 hours,” and meeting the sleep guideline was operationalized as “9 to 11 hours for those aged 5-13 years and 8-10 hours for those aged 14-17 years.” To obtain a complete profile of compliance with movement guidelines, two variables were used in this study: (a) number of the guidelines being met as a continuous variable (from 0 = “no guideline met” to 3 = “all three guidelines met”), and (b) combinations of the guidelines being met as a category variable (“none,” “only the PA guideline met,” “only the sedentary behavior guideline met,” “only the sleep guideline met,” “both the PA and sedentary behavior guidelines met,” “both the PA and sleep guidelines met,” and “all three guidelines met.”).

Body fat percentage was assessed using bioelectrical impedance analysis (BIA, Tanita, TBF-543, Japan). BIA is a valid measurement of body fat percentage in adolescents. To obtain accurate test results, we followed standard procedures and guidelines such as no beverage intake or engaging in MVPA for at least 12 hours prior to testing.

Covariates: Age, gender, perceived health status, life satisfaction, perceived sleep quality, and dietary intake were measured as covariates because they have the potential to influence adolescent adiposity indicators. Perceived health status was measured using one item (ie, “how is your health in general?”) on a 5-point Likert scale ranging from 1 (poor) to 5 (excellent). Life satisfaction was measured using one item (ie, “Are you satisfied with your life?”) on a 10-point Likert scale ranging from 1 (the worst life) to 10 (the best life). Participants reported their sleep quality in the recent month on a 4-Likert scale (ie, “During the past month, how would you rate your sleep quality overall?”) ranging from 1 (very bad) to 4 (very good). The Food Frequency Questionnaire-Short Form was used to evaluate dietary intake. Participants were asked to report daily servings of water, fruit, vegetables, dairy products, meat/fish/eggs, and carbohydrate on a 7-point Likert scale (1 = “none,” 7 = “six servings or above”).

2.3 Data analysis

Descriptive statistics including mean, standard division (SD), and percentages were evaluated first. City differences in compliance with 24-hour movement guidelines were tested using one-way ANOVA (dependent variable was number of the guidelines being met) and Chi-square statistics (dependent variable was combinations of the guidelines being met). Considering the hierarchical nature of the data (individual-level outcomes nested within schools), linear mixed-effects models were used to examine the associations between body fat percentage and meeting 24-hour movement guidelines. First, a null model that included only the dependent variable (ie, body fat percentage) and the cluster variable (ie, school) was tested to evaluate cluster effects. The intraclass correlation (ICC) was calculated as the school variance component divided by the total variance. Then, we examined two models that differed by the outcome variables: Model 1 included number of the guidelines being met as a continuous predictor and Model 2 included combinations of the guidelines being met as a category predictor. In Mode 1 and Model 2, the intercept for the dependent variable (ie, body fat percentage) was free to vary by school. City, age, gender, perceived health status, life satisfaction, perceived sleep quality, and dietary intake were added in the two models because they have the potential to influence the associations between body fat percentage and compliance with 24-hour movement guidelines. Gender (reference
category: female) and combinations of the guidelines being met (reference category: meeting none of the guidelines) were treated as categorical predictors in an ascending order during analyses. The others were treated as continuous predictors. For all models, parameter estimates were generated through restricted maximum likelihood estimation and statistical significance was set at \( P < .05 \). All analyses were performed using IBM SPSS Statistics 25 (Armonk, NY; IBM Corp, 2017).

### 3 | RESULTS

#### 3.1 | Descriptive characteristics of the sample

Table 1 presents descriptive characteristics of adolescent age, gender, MVPA, recreational screen time, sleep duration, and body fat percentage. The sample consisted of 12,590 adolescents (\( M_{\text{age}} = 13.63 \) years; \( SD = 1.01 \)). There were 47.9% girls (n = 6027, \( M_{\text{age}} = 13.62 \) years, \( SD = 1.01 \)), 52.1% boys (n = 6561, \( M_{\text{age}} = 13.65 \) years, \( SD = 1.02 \)), and two missing values in gender. On average per day, the adolescents spent 36.78 (± 34.74) minutes in MVPA, 4.07 (± 1.82) hours in recreational screen time, and they slept 7.72 (± 1.13) hours per night. In addition, the adolescents had an average of 22.34 (± 10.03) body fat percentage.

#### 3.2 | City differences in adolescents meeting the 24-hour movement guidelines

Table 2 shows city differences in compliance with 24-hour movement guidelines in Asian adolescents. There was a significant difference in number of the guidelines being met in adolescents across the eight Asian cities. On average, number of the guidelines being met in adolescents ranged from 1.45 ± 0.59 (Kuala Lumpur) to 1.81 ± 0.83 (Shanghai). City differences were also found for the combinations of the guidelines being met. Specifically, around 40% adolescents in Shanghai (42.2%) met none of guidelines, while 60% of adolescents in Kuala Lumpur met none of the guidelines. Less than 10% of adolescents in Bangkok, Hong Kong, and Taipei only met the PA guidelines, while around one in five adolescents in Tokyo met the PA guidelines. With the exception of adolescents in Shanghai (3%), less than 1% of adolescents from the other seven cities met all three guidelines.

### TABLE 1 | Descriptive characteristics of adolescents’ age, gender, moderate-to-vigorous physical activity, recreational screen time, sleep duration, and body fat percentage (N = 12,590)

| City            | Sample size, n | Schools, n | Age (year) M (SD) | Gender, girl, n % | MVPA (min/d), M (SD) | Screen time (h/d) M (SD) | Sleep duration, (h/d) M (SD) | Body fat percentage M (SD) |
|-----------------|----------------|------------|-------------------|-------------------|----------------------|--------------------------|-----------------------------|----------------------------|
| Bangkok         | 1118           | 11         | 13.95 (0.85)      | 556 (49.7%)       | 30.59 (30.24)        | 4.12 (1.98)              | 8.05 (1.03)                 | 23.55 (11.33)              |
| Hong Kong       | 1626           | 20         | 13.52 (0.97)      | 792 (48.7%)       | 25.53 (32.90)        | 4.50 (1.71)              | 7.75 (1.21)                 | 21.24 (10.10)              |
| Kuala Lumpur    | 1513           | 20         | 13.74 (1.03)      | 755 (49.9%)       | 33.59 (30.31)        | 5.27 (1.43)              | 7.87 (1.30)                 | 22.13 (9.50)               |
| Seoul           | 1686           | 7          | 13.35 (1.01)      | 784 (46.5%)       | 41.14 (34.69)        | 3.77 (1.72)              | 7.67 (0.98)                 | 24.90 (9.90)               |
| Shanghai        | 1599           | 7          | 14.01 (0.84)      | 785 (49.1%)       | 45.52 (31.41)        | 2.98 (1.53)              | 7.50 (1.23)                 | 22.23 (9.63)               |
| Singapore       | 1736           | 14         | 13.50 (1.21)      | 792 (45.6%)       | 40.71 (39.35)        | 3.82 (1.70)              | 7.56 (1.03)                 | 21.53 (10.21)              |
| Taipei          | 1620           | 4          | 13.84 (0.91)      | 765 (47.2%)       | 29.80 (31.69)        | 3.90 (1.76)              | 7.75 (1.01)                 | 23.29 (10.30)              |
| Tokyo           | 1692           | 5          | 13.30 (0.94)      | 798 (47.2%)       | 45.06 (44.71)        | 4.29 (1.88)              | 7.75 (1.16)                 | 20.15 (8.74)               |
| Total           | 12,590         | 88         | 13.63 (1.01)      | 6027 (47.9%)      | 36.78 (34.74)        | 4.07 (1.82)              | 7.72 (1.13)                 | 22.34 (10.03)              |

Abbreviations: M, mean; MVPA, moderate-to-vigorous physical activity; SD, standard deviation.
DISCUSSION

This study was the first to evaluate compliance with 24-hour movement guidelines in adolescents from eight Asian metropolises (N = 12,590). City differences were found in number of the guidelines being met and combinations of the guidelines being met. We also found that the number of the guidelines being met was negatively associated with body fat percent in Asian adolescents. Furthermore, meeting only the sleep guideline and both the PA and sleep guidelines had negative associations with body fat percentage compared with no guidelines being met. These findings are important for understanding 24-hour movement behaviors in Asian adolescents and for establishing evidence-based intervention for preventing overweight and obesity in adolescents.

A small proportion of Asian adolescents met the independent or combined guidelines for PA, sedentary behavior, and sleep. We found that around half of the Asian adolescents did not meet any of the three guidelines, and less than 1% of the adolescents met all three guidelines with the exception of those from Shanghai (3%). Similar results were reported for adolescents from other countries and subnational regions such as Canada, Hong Kong, and Korea. These findings suggest that it is common for adolescents worldwide to spend too much time on screens and fail to engage in sufficient PA or sleep. Our results are also consistent with previous studies in which PA, sedentary time, and sleep duration were assessed using objective measurements. A small proportion of Asian adolescents met the independent or combined guidelines for PA, sedentary behavior, and sleep. We found that a) half of the adolescents met all three guidelines, and b) the guidelines being met and combinations of the guidelines being met had negative associations with body fat percentage compared with no guidelines being met. Furthermore, meeting only the sleep guideline was negatively associated with body fat percentage.

City differences were found in number of the guidelines being met and combinations of the guidelines being met. These findings suggest that it is common for adolescents worldwide to spend too much time on screens and fail to engage in sufficient PA or sleep. Our results are also consistent with previous studies in which PA, sedentary time, and sleep duration were assessed using objective measurements. These findings suggest that it is common for adolescents worldwide to spend too much time on screens and fail to engage in sufficient PA or sleep. Our results are also consistent with previous studies in which PA, sedentary time, and sleep duration were assessed using objective measurements.

TABLE 2
City differences in compliance with 24-hour movement guidelines in Asian adolescents

| City     | Number of the guidelines being met, M (SD) | Combinations of the guidelines being met, n (%) |
|----------|-------------------------------------------|-------------------------------------------------|
|          | None | Only PA | Only Sleep | Only SB | PA + Sleep | PA + SB | Sleep + SB | All       |
| Total    | 1.60 (0.70) | 4038 (51.1%) | 989 (12.5%) | 1548 (19.6%) | 493 (6.2%) | 347 (4.4%) | 190 (2.4%) | 227 (2.9%) | 67 (0.8%) |
| Bangkok  | 1.65 (0.66) | 332 (44.7%) | 54 (7.3%) | 266 (35.8%) | 21 (2.8%) | 30 (4.0%) | 11 (1.5%) | 24 (3.2%) | 4 (0.5%) |
| Hong Kong| 1.50 (0.63) | 466 (57.2%) | 70 (8.6%) | 202 (24.8%) | 20 (2.5%) | 35 (4.3%) | 5 (0.6%) | 16 (2.1%) | 1 (0.1%) |
| Kuala Lumpur | 1.45 (0.59) | 812 (60%) | 154 (11.4%) | 317 (23.4%) | 1 (0.1%) | 68 (5.0%) | 1 (0.1%) | 0 (0.0%) | 0 (0.0%) |
| Seoul    | 1.60 (0.68) | 472 (51.2%) | 128 (13.9%) | 140 (15.2%) | 89 (9.7%) | 37 (4.0%) | 29 (3.1%) | 21 (2.3%) | 6 (0.7%) |
| Shanghai | 1.81 (0.83) | 595 (42.2%) | 174 (12.3%) | 181 (12.8%) | 171 (12.1%) | 63 (4.5%) | 80 (5.7%) | 104 (7.4%) | 42 (3.0%) |
| Singapore| 1.61 (0.67) | 417 (49.6%) | 157 (18.7%) | 111 (13.2%) | 71 (8.4%) | 33 (3.9%) | 31 (3.7%) | 18 (2.1%) | 3 (0.4%) |
| Taipei   | 1.53 (0.66) | 615 (55.4%) | 94 (8.5%) | 231 (20.8%) | 83 (7.5%) | 36 (3.2%) | 13 (1.2%) | 32 (2.9%) | 7 (0.6%) |
| Tokyo    | 1.65 (0.69) | 329 (46.7%) | 158 (22.4%) | 100 (14.2%) | 37 (5.2%) | 45 (6.4%) | 20 (2.8%) | 12 (1.7%) | 4 (0.6%) |

City differences F (7, 7891) = 33.82, P < .001 χ² (49, N = 7899) = 977.11, P < .001

Abbreviations: PA, physical activity; SB, sedentary behavior.

Children and adolescents aged 5 to 17 y are recommended for engaging in at least 60 min of moderate-to-vigorous physical activity (MVPA) and several hours of light PA per day, spending no more than 2 h in recreational screen time, reducing sitting for extended periods, and sleeping 9-11 h for those aged 5-13 y and 8-10 h for those aged 14-17 y.

TABLE 3
Associations between number of the 24-h movement guidelines being met and body fat percentage in Asian adolescents

| Predictors | β | SE | 95% CI | P |
|------------|---|----|--------|---|
| Intercept  | 3.20 | 0.69 | 2.11 to 4.37 | <.001 |
| Covariates | | | | |
| City | 0.20 | 0.10 | 0.01 to 0.39 | .010 |
| Age | 0.11 | 0.04 | 0.02 to 0.20 | .001 |
| Gender (male as reference) | -8.38 | 0.22 | -8.81 to -7.94 | <.001 |
| Perceived health | -1.30 | 0.10 | -1.50 to -1.10 | <.001 |
| Life satisfaction | -0.24 | 0.05 | -0.34 to -0.14 | .001 |
| Dietary intake | 0.01 | 0.07 | 0.00 to 0.01 | .070 |
| Physical activity | 0.02 | 0.06 | 0.00 to 0.04 | .020 |
| Sleep duration | 0.02 | 0.06 | 0.00 to 0.04 | .010 |

Abbreviations: 95% CI, 95% confidence intervals; β, standardized coefficient; SE, standard error.
and found that the prevalence of children meeting all three guidelines was 7%. These findings suggest that insufficient compliance with 24-hour movement guidelines in children and adolescents is a global issue, regardless the use of self-reported data or data from objective measurements. Effective policies need to be implemented to help children and adolescents adopt healthy lifestyles and to provide more active facilities for PA in urban parks, playgrounds, and other community settings.34

The number of guidelines being met and combinations of guidelines being met differed in adolescents across the eight Asian sites. We found that the mean values of the number of guideline being met ranged from 1.45 (Kuala Lumpur) to 1.81 (Shanghai). With the exception of adolescents in Shanghai (3%), less than 1% of adolescents from the other seven cities met all three guidelines. The relatively high proportion of meeting all three guidelines in Shanghai can be explained by national policies with respect to physical education (PE) and sport initiatives that promote awareness on the part of adolescents about engaging in active recreation.34 For example, the government of China requires all children and adolescents to conduct at least two hours of PE classes per week.34 This result can also be explained by the high walkability in mainland China that facilitates active travel to schools, active play in leisure time, and independent mobility.35 An additional explanation for the result is that limits on recreational screen time from Chinese parents may attenuate the screen use in adolescents.36 To promote a healthy lifestyle during adolescence, effective strategies are needed to increase the compliance with 24-hour movement guidelines in Asian adolescents.

A negative association between number of the guidelines being met and body fat percent was observed in Asian adolescents. In line with our finding, a cross-sectional study of 9589 American adolescents found that those who did not meet any of the movement guidelines were more likely to be obese.4 Similarly, another cross-sectional study of American children aged 7-12 years found that children meeting all three guidelines were the least likely to be obese. Our finding suggests that Asian adolescents meeting more movement guidelines for PA, sedentary behavior, and sleep were more likely to have lower percentage of body fat. An understanding of this finding is that the Asian adolescents meeting more guidelines had healthy lifestyles such as sufficient PA, reduced sedentary activities, and adequate sleep. These healthy lifestyle behaviors may reduce a risk of overweight and obesity in Asian adolescents. It should be acknowledged that current evidence for the association between number of 24-hour movement guidelines and adiposity in adolescents is still understudied. Future research is recommended for using longitudinal study designs to examine the potential direction of the associations.

Sufficient amount of nightly sleep is required for preventing obesity in adolescents.37 In line with previous evidence,37 we found a negative association between meeting the sleep guideline and body fat percentage in adolescents. This result raises the possibility that adequate sleep duration may help adolescents control appetite, adopt healthy dietary habits (such as reduced late-night eating), and consequently control body weight.37,38 Moreover, we found that adolescents meeting both the PA and sleep guidelines were more likely to have lower odds ratios for body fat percentage compared with those meeting none of the guidelines. This finding suggests that a combination of adequate nightly sleep and sufficient PA provides beneficial effects on maintaining a healthy body weight in adolescents. It is not supervising that physically active adolescents with adequate sleep duration would have lower body fat percentages. Yet, this study did not observe a significant association between meeting all three guidelines and body fat

| TABLE 4 | Associations between combinations of the 24-h movement guidelines being met and body fat percentage in Asian adolescents |
|----------|--------------------------------------------------------------------------------|
| Predictors | $\beta$ | SE | 95% CI | $P$ |
| Intercept | 3.18 | 0.68 | 2.08 to 4.85 | <.001 |
| Covariates | | | | |
| City | 0.19 | 0.10 | 0.00 to 0.38 | .444 |
| Age | 0.08 | 0.12 | −0.15 to 0.31 | .492 |
| Gender (reference: female) | −8.38 | 0.22 | −8.81 to −7.94 | <.001 |
| Perceived health status | −1.33 | 0.14 | −1.61 to −1.05 | <.001 |
| Life satisfaction | −0.04 | 0.06 | −0.16 to 0.08 | .531 |
| Perceived sleep quality | −0.27 | 0.14 | −0.55 to 0.01 | .056 |
| Dietary intake | 0.82 | 0.18 | 0.48 to 1.17 | <.001 |

Combinations of the guidelines being met

- None | Ref | Ref | Ref | Ref |
- Only physical activity | −0.01 | 0.33 | −0.66 to 0.65 | .984 |
- Only sleep | −0.07 | 0.28 | −1.53 to −0.42 | .001 |
- Only sedentary behavior | −0.31 | 0.45 | −1.20 to 0.57 | .488 |
- Physical activity + sleep | −1.27 | 0.53 | −2.31 to −0.23 | .017 |
- Physical activity + sedentary behavior | 0.30 | 0.71 | −1.10 to 1.70 | .675 |
- Sleep + sedentary behavior | −0.57 | 0.63 | −1.81 to 0.67 | .367 |
- All | −0.75 | 1.16 | −3.03 to 1.53 | .521 |

Abbreviations: 95% CI, 95% confidence intervals; SE, standard error; $\beta$, standardized coefficient.
percentage, with the reference category of meeting none of the guideline. A possible explanation for this finding is that using a dummy variable might not be very “significant” from a practical perspective because the category groups had an uneven distribution, with 51.1% of the adolescents met none of the guidelines and only 0.8% met all three guidelines. Experimental studies are recommended in future research to explore how compliance with all three guidelines for PA, sedentary behavior, and sleep affects adiposity in adolescents.

4.1 Study strengths and limitations

Strengths of this study include a comprehensive evaluation of compliance with 24-hour movement guidelines in a large and representative sample of Asian-wide adolescents. This is the first study to compare number of guidelines being met and combinations of guidelines being met across eight megacities in Asia. This study also augments the current body of evidence on the association between meeting the 24-hour movement guidelines and body fat percentage in adolescents.

Limitations of this study should also be identified. First, the cross-sectional design limited understanding of the causal relationships between movement behaviors and adiposity. Future research may consider using longitudinal designs to evaluate compliance with 24-hour movement guidelines from childhood to adolescence and to strengthen the evidence base regarding how compliance with 24-hour movement guidelines affect changes in adiposity indicators in the long term. Second, adolescent movement behaviors were estimated using self-reported scales instead of objective measurements. The self-reported scale of IPAQ-SF made it impossible to measure number of steps a day and estimate light PA, although increasing light PA has been highlighted in 24-hour movement guidelines. Objective measurements such as accelerometer can reduce overestimation of PA and sleep duration caused by social desirability response bias. Using objective measurements can also increase the measurement accuracy of intensity levels and time spent at MVPA, number of steps, and sleep duration. Future research is therefore recommended to objectively assess PA and sleep duration using 24-hour accelerometers over seven consecutive days.

Third, we did not compare adolescent movement behaviors between weekdays and weekends, which should be an important focus in future research because previous studies revealed differences in weekday-weekend patterns of PA in adolescents. Fourth, although the adolescents were asked to report their parents’ socioeconomic statuses (ie, educational levels, family income, and jobs), socioeconomic status was not included in the analyses because these variables were missing in some countries. Finally, we did not consider the issue of physical growth and maturation which may influence body fat percentage.

In summary, the current study was the first to evaluate compliance with 24-hour movement guidelines in adolescents throughout Asia. Given that only 1%–3% adolescents meet all three movement guidelines, effective strategies are needed to promote healthy lifestyles in Asian adolescents. To improving empirical evidence for development of evidence-based 24-hour movement guidelines for Asian young people, future research is recommended for using prospective and intervention designs to examine the associations between compliance with 24-hour movement guidelines and relevant health outcomes in Asian adolescents. To developing the guideline for sedentary behavior (eg, the limits of sitting), future research is also recommended for using objective measurements to test sitting time during a 24-hour period and for developing an operational definition of meeting the guideline for sedentary behavior in adolescents.

5 PERSPECTIVE

This study provides a clear picture of compliance with 24-hour movement guidelines in adolescents across eight Asian countries and regions. Specifically, Asian adolescents meeting more movement guidelines for PA, sedentary behavior, and sleep were more likely to have lower percentage of body fat. In addition, adequate nightly sleep and sufficient PA had good effects on weight control in adolescents. Our findings improve better understanding about how compliance with 24-hour movement guidelines benefit a healthy body weight in adolescents, as well as contribute to development of evidence-based 24-hour movement guidelines for Asian young people. Prospective follow-up studies are warranted to gain better insights into the directionality of the associations between compliance with 24-hour movement guidelines and adiposity, as well as the mechanisms underlying these associations in Asian young people.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.
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