The Associations between Meeting the 24-Hour Movement Guidelines and Adiposity in Asian Adolescents: The Asia-Fit Study

Stanley Hui (stanley.hui36081@gmail.com)
Chinese University of Hong Kong

Ru Zhang
Chinese University of Hong Kong

Koya Suzuki
Juntendo Daigaku

Hisashi Naito
Juntendo Daigaku

Govindasamy Balasekaran
Nanyang Technological University

Jong-Kook Song
Kyung Hee University

Soo Yeon Park
Yong In University

Yiing-Mei Liou
National Yang-Ming University

Dajiang Lu
Shanghai University of Sport

Bee Koon Poh
Universiti Kebangsaan Malaysia

Kallaya Kijboonchoo
Mahidol University

Wiyada Thasanasuwan
Mahidol University

Research

Keywords: Adolescent health, cross-cultural comparison, physical activity, recreational screen-time, sleep duration, movement behaviours, obesity

Posted Date: March 23rd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-18510/v1

Version of Record: A version of this preprint was published at Scandinavian Journal of Medicine & Science in Sports on December 12th, 2020. See the published version at https://doi.org/10.1111/sms.13893.

Abstract

Background: To prevent adolescent obesity, recent research suggests that physical activity (PA), recreational screen-time, and sleep duration are codependent behaviours that being in a movement behaviour continuum in a 24-hour period. Yet, it is unknown about compliance with the 24-hour movement guidelines in Asian adolescents, and how these movement behaviours collectively affect overweight and obesity in adolescents. The purposes of this study were to compare compliance with the 24-movement guidelines in Asian adolescents, as well as to examine the association between meeting the 24-hour movement guidelines and body fat percentage.

Methods: 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) participated this study. The adolescents were asked to complete an interviewer-administered questionnaire to assess moderate-to-vigorous PA, recreational screen-time, sleep duration, and covariates. Adolescent's body fat percentage was assessed using bioelectrical impedance analysis.

Results: Findings show that a small proportion of Asian adolescents met the independent or combined guidelines of PA, recreational screen-time, and sleep duration. In addition, number of the guideline being met and combinations of the guidelines being met differed across the eight cities. Adjusting for covariates, we observed a negative association between number of the guidelines being met and body fat percent in Asian adolescents. In addition, meeting only the sleep duration guideline and both the physical activity and sleep duration guidelines had negative associations with body fat percentage compared with no guidelines being met.

Conclusions: The current study was the first to evaluate compliance with the 24-hour movement guidelines in Asia-wide adolescents. Given only 1%-3% adolescents met all three movement guidelines, global strategies are needed to promote healthy lifestyles in adolescents. This study also provides primary evidence on the association between compliance with the 24-hour movement guidelines and adiposity in adolescents. Prospective follow-up studies are warranted to gain better insights into the compliance with 24-hour movement guidelines and the related health outcomes to contribute to the growth of evidence in this area.

Introduction

Adolescent obesity is one of the most prevalent health issues around the world (1). The number of obese children and adolescents aged 5-19 years has increased from 11 million in 1975 to 124 million in 2016 (2). The increasing trends in obesity seem to be plateauing in children, but continue to accumulate in adolescents, especially in Asia (2, 3). Evidence indicates that obese adolescents are more likely to stay overweight into adults, and have larger risks in non-communicable diseases such as cardiovascular diseases, type 2 diabetes, high blood pressure through the life course (1, 4). Findings also represent a positive association between obesity and adverse psychosocial consequences such as depression and emotional disorders in adolescents (5, 6). Despite the adverse physical and mental health consequences, overweight and obesity is largely preventable in adolescence (2, 7). Preventive action should therefore targets modifiable factors to reduce adiposity in Asian adolescents.

To prevent overweight and obesity in adolescents, recent research suggests that physical activity (PA), recreational screen-time, and sleep duration are codependent behaviours that being in a movement behaviour continuum in a 24-hour period (8). From such a movement continuum perspective, children and adolescents aged 5 to 17 years are recommended to engage in at least 60 minutes of moderate-to-vigorous PA (MVPA), spend no more than 2 hours in recreational screen-time, and sleep 9-11 hours for those aged 5-13 years and 8-10 hours for those aged 14-17 years

in daily life (9). Still, data on the movement behaviours are common for preschool- and school-aged children (Carson, Tremblay, & Chastin, 2017; Chaput et al., 2017; Walsh et al., 2018), and only few research has shown this knowledge in adolescents (10-12). A recent study found that 17.1% Canadian adolescents aged 12-17 years did not meet any of the PA, recreational screen-time, sleep duration guidelines and only 5.5% of those met all the three guidelines (10). Similar results were also revealed in Hong Kong and Korea adolescents (11, 12). Accordingly, the question of adolescents' compliance with the 24-hour movement guidelines has not been fully examined and more research is needed. Such information enables researchers to monitor health risks and develop effective strategies in preventing overweight and obesity in adolescents (13).

Studies have well established that MVPA, recreational screen-time, and sleep duration were independently related to adiposity indicators such as body mass index (BMI) and fat mass percent in adolescents (14-16). Yet, it is still unknown how these movement behaviours collectively affect overweight and obesity in adolescents. Few studies have examined the associations of adiposity indicators with number of the guidelines being met and combinations of the guidelines being met, still, the available evidence lacks for consistency (17, 18). Some studies found that children and adolescents meeting all the three guidelines had lower odds ratios for BMI compared with those meeting none of the guidelines (11, 19, 20), while others have found that combinations of the guideline met did not associate with BMI (17, 21). Further research is warranted to enrich the knowledge on how combinations of the 24-hour movement guidelines being met affect overweight and obesity in adolescents.

Multi-country data on compliance with the 24-hour movement behaviours are rare in current evidence, with an exception of one study in which older children's movement behaviours were investigated in 12 countries with a wide range of economic and demographic characteristics (19). In Asia, adolescents' 24-hour movement behaviours have been investigated in Korea and Hong Kong (11, 12). Despite both of the two studies used nationally representative samples, a wide variety of sampling strategies and a lack of standardized and validated measurements make it difficult to evaluate inter-country differences in compliance with the 24-hour movement behaviours in Asian adolescents. Furthermore, examining data under different cultural and economic contexts can improve an understanding of the generalizability of the direction (22). Data collected in a single country or subnational region may show limited variance and results (19).

The purposes of this study were to compare compliance with the 24-movement guidelines in Asian adolescents, as well as to examine the association between meeting the 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 across cities (19, 23), and (b) number of the guidelines being met and combinations of the guidelines being met would be associated with body fat percentage in adolescents (19, 20).

Methods

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 the health-related fitness, movement behaviours, and body fat percentage in Asian adolescents. We selected these cities because they (a) could represent the most important metropolises in Asian countries and within-country regions, and (b) differ by geography, culture, and ethnicity. A detailed description of the study design and sampling methodology can be

found elsewhere (24). 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 that could 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, characterised by significant changes in their lifestyle behaviours such as increased recreational screen-time (25).

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, scoring were consistent in the eight cities by using the same operational procedures. The ethical committee on the Use of Human & Animal Subjects in Teaching and Research (HASC) in each study city approved this study.

Measures

Participants completed an interviewer-administered survey regarding MVPA, recreational screen-time, sleep duration, and covariates, and finished a test of body fat percentage during a physical education lesson 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 (26). Participants reported the frequency (times/week) and duration (minutes/time) of walking, moderate activities, and vigorous activities in the last seven days. We only considered the activities that were performed in bouts of at least 10 minutes in duration. The frequency and duration were multiplied to calculate minutes of the 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 (27). Participants reported their time spent on recreational screen activities such as watching TV, using internet, and playing video games separately for a typical weekday and weekend. According to previous studies (28), recreational screen-time (hours/day) was calculated by weighting the responses (screen time $_{weekday}$ × 5+screen time $_{weekend}$ × 2)/7.

Sleep duration. Participants reported the bedtime and wake up time separately for a typical weekday and weekend. We calculated the participants' sleep duration by weighting the responses (sleep time $_{weekday}$ × 5+sleep time $_{weekend}$ × 2)/7.

According to the 24-hour movement guidelines for adolescents (20), meeting the PA guideline was operationalized as 'average daily MVPA is at least 60 minutes per day', meeting the recreational screen-time guideline was operationalized as 'no more than 2 hours', and meeting the uninterrupted sleep guideline was operationalized as '9 to 11 hours for 5-13 years and 8-10 for 14-17 years'. To have a complete profile of compliance with the movement guidelines, two variables were used in this study: (a) number of the guidelines being met as a continuous variable (from 0 = '*none guideline met*' to 3 = '*all three guideline met*'), and (b) combinations of the guidelines being met as a category variable ('*none*', '*only the PA guideline met*', '*only the screen time guideline met*', '*only the sleep duration guideline met*', '*both of the PA and screen time guidelines met*', '*both of the screen time and sleep duration guidelines met*', '*both of the PA and sleep duration 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 (29). To 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 (30).

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 the adolescents' adiposity indicators (31, 32). *Perceived health status* was measured using one item (i.e., 'How do you think about your health?') on a 5-point Likert scale ranging from 1 (*very bad*) to 5 (*very good*). *Life satisfaction* was measured using one item (i.e., 'Are you satisfied about 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 (i.e., 'How well your sleep in the recent month?') ranging from 1 (*very bad*) to 4 (*very good*). The Food Frequency Questionnaire-Short Form (FFQ-SF) was used to evaluate the adolescents' *dietary intake* (33). Participants were asked to report daily servings of water, fruit, vegetables, dairy products, meat/fish/eggs and carbohydrate on 7-point Likert scale (1= "*none*", 7= "*six servings or above*").

Data analysis

Data were analysed using IBM SPSS Statistics 25 (Armonk, NY; IBM Corp, 2017). Descriptive statistics including mean, standard division (*SD*), and percentages were evaluated. City differences in number of the guidelines being met and combinations of the guidelines being met were tested using one-way ANOVA and Chi-square statistics, respectively. 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 the 24-hour movement guidelines. Firstly, a null model that included only the dependent variable (i.e., body fat percentage) and the cluster variable (i.e., school) was tested to evaluate cluster effects. Then, we examined two models that differed by the guidelines met variables: Model 1 included number of the guidelines being met as a continuous variable and Model 2 included combinations of the guidelines being met as a category variable. In both of the two-level mixed effects models, the intercept for the dependent variable (i.e., body fat percentage) was free to vary by school. City, age, gender, perceived health status, life satisfaction, perceived sleep quality, dietary intake were added in the two models 2 as covariates because they have the potential to influence adolescents' adiposity (23, 34). All the effect sizes were considered to be statistically significant when the *p*-value was less than 0.05.

Results

Descriptive characteristics of the sample

Table 1 presents descriptive characteristics of adolescents' age, gender, MVPA, recreational screen-time, sleep duration, and body fat percentage. The sample consisted of 12,590 adolescents (M_{age} = 13.63 years; *SD* = 1.01). There were 47.9% girls (*n* = 6,027, M_{age} = 13.62 years, *SD* = 1.01), 52.1% boys (*n* = 6,561, M_{age} = 13.65 years, *SD* = 1.02), and two missing values in gender. On average, the adolescents spent 257.47 (± 243.17) minutes per week in MVPA and 4.07 (± 1.82) hours per day in recreational screen-time, and daily slept 7.72 (± 1.13) hours. In addition, the adolescents had an average of 22.34 (± 10.03) body fat percentage.

City differences in adolescents meeting the 24-hour movement guidelines

Table 2 shows city differences in Asian adolescents meeting the 24-hour movement guidelines. City differences were identified in number of the guidelines being met (F (7, 7891) = 33.82, p < .001). On average, the adolescents met a number of 1.45 (SD = 0.59) to 1.81 (SD = 0.83) guidelines. City differences were also identified in the combinations of the guidelines being met (χ^2 (49, N = 7899) = 977.11, p < .001). Around 40% adolescents in Shanghai (42.2%) and Bangkok (44.7%) met none of the PA, recreational screen-time, and sleep duration guidelines, while more than half of adolescents in Seoul (51.2%), Taipei (55.4%), Hong Kong (57.2%), and Kuala Lumpur (60%) did not reach any of the three guidelines. Less than 10% of adolescents met two types of guidelines (i.e., PA + screen time, PA+ sleep duration, or screen time + sleep duration). Except adolescents in Shanghai (3%), less than 1% of adolescents from the other seven cities met all the three guidelines.

Associations between body fat percentage and meeting the 24-hour movement guidelines

Table 3 and Table 4 represent the associations of body fat percentage with number of the guidelines being met and combinations of the guidelines being met. As Table 3 shows, number of the guidelines being met was negatively associated with body fat percentage in adolescents (β = -0.40, 95% CI = -0.71 to -0.10, p = .010) after adjusting for region, age, gender, perceived health status, life satisfaction, perceived sleep quality, and dietary intake. In Table 4, meeting only the sleep duration guideline (β = -0.97, 95% CI = -1.53 to -0.42, p = .001) and both the PA and sleep duration guidelines (β = -1.27, 95% CI = -2.31 to -0.23, p = .017) were negatively associated with body fat percentage compared with no guidelines being met. The associations were not significant between body fat percentage and the other combinations of guideline met (i.e., only PA, only screen time, PA+ screen time, sleep duration + screen time, and all guidelines being met).

Discussion

This study was the first to evaluate compliance with the 24-movement guidelines in Asia-wide adolescents (N = 12,590). City differences were revealed in number of the guidelines being met and combinations of the guidelines being met. Findings also show that number of the guidelines being met was negatively associated with body fat percent in Asian adolescents. Further, meeting only the sleep duration guideline and both the PA and sleep duration guidelines had negative associations with body fat percentage compared with no guidelines being met. These findings are important for understanding the 24-hour movement behaviours in Asian adolescents and for establishing evidence-based intervention targets for preventing overweight and obesity in adolescence.

A small proportion of Asian adolescents met the independent or combined guidelines of PA, recreational screen-time, and sleep duration. 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 the three guidelines with an exception of those from Shanghai (3%). Similar results have been revealed in adolescents from other countries and subnational regions such as Canada (10), Hong Kong (11) and Korea (12). These findings suggest that it is common for adolescents worldwide to spend too much time on screens and do not engage in sufficient PA or sleep. This study also found that number of guidelines being met and combinations of guidelines being met differed across the eight Asian sites. Findings show that the mean values of number of guideline being met ranged from 1.45 (Kuala Lumpur) to 1.81 (Shanghai). In addition, except adolescents in Shanghai (3%), less than 1% of adolescents from the other seven cities met all three guidelines. These results indicate that Shanghai is ahead of other cities with regard to the compliance with 24-hour movement guidelines. A possible explanation is that the sport initiatives that are organized by Chinese governments and schools can promote adolescents' awareness about engaging in active recreation in daily life. A further explanation is that limits on recreational screen-time from Chinese parents may

attenuate the screen use in adolescents (35). To promote a healthy lifestyle in adolescents, global strategies are needed to increase the compliance with 24-hour movement guidelines in adolescents.

A negative association between number of the guidelines being met and body fat percent was observed in Asian adolescents. In line with this finding, a cross-sectional study of 9,589 American adolescents found that larger odds of obesity were observed in those who did not meet any of the movement guidelines (16). Similarly, another cross-sectional study of American children aged 7-12 years from Laurson and colleges found that children meeting all three guidelines were the least likely to be obese (15). These evidence suggests that adolescents meeting fewer guidelines are more likely to be overweight or obese. It should be acknowledged that evidence on the association between number of movement guidelines and adiposity is still understudied. Future research is recommended to use longitudinal study design to examine the potential direction of the associations.

Sufficient amount of nightly sleep is required for preventing obesity in adolescents (36). In line with previous evidence (36, 37), our results revealed a negative association between meeting the sleep duration guideline and body fat percentage in adolescents. Recent studies have shown that increasing nightly sleep can help them control appetite, have healthy dietary habits, and body weight (38). Our findings raise a possibility that adequate sleep may link to reduced late-night eating which has some contributions to body composition in adolescents (39). Moreover, we found that adolescents meeting both of the PA and sleep duration 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 sufficient nightly sleep needs to be combined with meeting the PA guideline to bring better effects on weight control in adolescents. It is not supervising that active adolescents with adequate sleep duration would have lower body fat percentage. Future research should establish directionality of the associations between PA, sleep duration, and adiposity, as well as the mechanisms underlying the associations.

Study strengths and limitations

Strengths of this study include a comprehensive evaluation compliance with the 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 enriches current 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 the causal relationships between movement behaviours and adiposity. Future research may consider using longitudinal and exponential designs to evaluate compliance with the 24-hour movement guidelines from children to adolescents and to strengthen the evidence base on how compliance with the 24-hour movement guidelines affect changes in adiposity indicators in the long term (40). Second, adolescents' movement behaviours were estimated using self-reported scales instead of objectively-measured tools. To reduce potential measurement bias, future research may consider objectively examining compliance with the movement guidelines using objectively-measured tools. Third, we did not compare the adolescents' movement behaviours between weekday and weekend, which should be an important focus in future research (20). Fourth, although the adolescents were asked to report their parents' socioeconomic status (i.e., educational levels, family income, and jobs), parents' socioeconomic status (SES) was not included in the analyses because these variables were missing in some countries. Last, this study did not consider the issue of physical growth and maturation which may influence adolescents' body fat (41).

Conclusions

The current study was the first to evaluate compliance with 24-hour movement guidelines in Asia-wide adolescents. Given only 1%-3% adolescents met all three movement guidelines, global strategies are needed to promote healthy lifestyles in adolescents. Furthermore, this study provides primary evidence on the association between compliance with 24-hour movement guidelines and adiposity in adolescents. Prospective follow-up studies are warranted to gain better insights into the compliance with 24-hour movement guidelines and the related health outcomes to contribute to the growth of evidence in this area.

Declarations

Ethics approval and consent to participate

The ethical committee on the Use of Human & Animal Subjects in Teaching and Research (HASC) in each study city approved this study. Participants provided written consent signed by their legal guardians.

Consent for publication

N/A

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interest to disclose. The funding organization had no involvement in study design, data collection, data analysis, interpretation of data, and the writing of manuscript.

Funding

This work was supported by the NUS Initiative to Improve Health in Asia (NIHA) research grant (NIHA-2011-1-007), which was supported by the Glaxo Smith Kline-Economic Development Board (Singapore) Trust Fund and coordinated by the Global Asia Institute of the National University of Singapore.

Authors' contributions

SSCH developed the study concept and design. KS, HN, GB, JKS, SYP, YML, DL, BKP, KK, WT acquired the data. RZ performed the statistical analysis of the data and was a major contributor in writing the manuscript. All authors approved the final version as submitted.

Acknowledgements

N/A

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Tables

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	Age (yr.) M (SD)	Gender, girl, n %	MVPA (min·w^{-1}), M (SD)	Screen time (h·d^{-1}) M (SD)	Sleep duration, (h·d^{-1}) M (SD)	Body fat percentage M (SD)
Bangkok	1,118	13.95 (0.85)	556 (49.7%)	214.14 (211.65)	4.12 (1.98)	8.05 (1.03)	23.55 (11.33)
Hong Kong	1,626	13.52 (0.97)	792 (48.7%)	178.70 (230.31)	4.50 (1.71)	7.75 (1.21)	21.24 (10.10)
Kuala Lumpur	1,513	13.74 (1.03)	755 (49.9%)	235.14 (212.16)	5.27 (1.43)	7.87 (1.30)	22.13 (9.50)
Seoul	1,686	13.35 (1.01)	784 (46.5%)	287.99 (242.85)	3.77 (1.72)	7.67 (0.98)	24.90 (9.90)
Shanghai	1,599	14.01 (0.84)	785 (49.1%)	318.65 (219.88)	2.98 (1.53)	7.50 (1.23)	22.23 (9.63)
Singapore	1,736	13.50 (1.21)	792 (45.6%)	284.98 (275.42)	3.82 (1.70)	7.56 (1.03)	21.53 (10.21)
Taipei	1,620	13.84 (0.91)	765 (47.2%)	208.57 (221.85)	3.90 (1.76)	7.75 (1.01)	23.29 (10.30)
Tokyo	1,692	13.30 (0.94)	798 (47.2%)	315.43 (312.96)	4.29 (1.88)	7.75 (1.16)	20.15 (8.74)
Total	12,590	13.63 (1.01)	6,027 (47.9%)	257.47 (243.17)	4.07 (1.82)	7.72 (1.13)	22.34 (10.03)

Note. MVPA = Moderate-to-vigorous physical activity, M = Mean, SD = Standard deviation,

Table 2.

City differences in adolescents meeting the 24-hour movement guidelines [a]

City	Number of the guidelines being met, *M* (*SD*)	Combinations of the guidelines being met, *n* (%)							
		None	Only PA	Only Sleep	Only ST	PA + Sleep	PA + ST	Sleep + ST	All
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 (2.09%)	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, $p < .001$							χ^2 (49, N = 7899) = 977.11, $p < .001$	

Note. [a] Children and adolescents aged 5 to 17 years are recommended to engage in at least 60 minutes of moderate-to-vigorous physical activity, spend no more than 2 hours in recreational screen-time, and sleep 9-11 hours for those aged 5-13 years and 8-10 hours for those aged 14-17 years in daily life (9).

PA = Physical activity, ST = Screen time,

Table 3.

Associations between number of the 24-hour movement guidelines being met and body fat percentage in adolescents

Predictors	β	SE	95% CI	p
Intercept	3.20	0.69	2.11 to 4.87	<.001
Covariates				
City	0.20	0.10	0.01 to 0.39	.040
Age	0.02	0.11	-0.20 to 0.25	.833
Gender (reference: female)	-8.38	0.22	-8.81 to -7.94	<.001
Perceived health status	-1.30	0.14	-1.58 to -1.02	<.001
Life satisfaction	-0.04	0.06	-0.16 to 0.08	.500
Perceived sleep quality	-0.24	0.14	-0.52 to 0.04	.091
Dietary intake	0.85	0.18	0.50 to 1.19	<.001
Number of the guidelines being met	-0.40	0.16	-0.71 to -0.10	.010

Note. β = Standardised coefficient; *SE* = Standard error; 95% CI = 95% confidence intervals.

Table 4.
Associations between combinations of the 24-hour movement guidelines being met and body fat percentage in adolescents

Predictors	β	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	.044
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 duration	-0.97	0.28	-1.53 to -0.42	.001
Only screen time	-0.31	0.45	-1.20 to 0.57	.488
Physical activity + sleep duration	-1.27	0.53	-2.31 to -0.23	.017
Physical activity + screen time	0.30	0.71	-1.10 to 1.70	.675
Sleep duration + screen time	-0.57	0.63	-1.81 to 0.67	.367
All	-0.75	1.16	-3.03 to 1.53	.521

Note. β = Standardised coefficient; *SE* = Standard error; 95% CI = 95% confidence intervals.

STROBE Statement—checklist of items that should be included in reports of the study

	Item No	Recommendation	Checklist
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	√
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	√
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	√
Objectives	3	State specific objectives, including any prespecified hypotheses	√
Methods			
Study design	4	Present key elements of study design early in the paper	√
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	√
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	√
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	√
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	√
Bias	9	Describe any efforts to address potential sources of bias	√
Study size	10	Explain how the study size was arrived at	n/a
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	√
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	√
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	√
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	n/a

Continued on next page

Results			**Checklist**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	√
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	√
		(b) Indicate number of participants with missing data for each variable of interest	n/a
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	n/a
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	n/a
		Cross-sectional study—Report numbers of outcome events or summary measures	√
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	√
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n/a
Discussion			
Key results	18	Summarise key results with reference to study objectives	√
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	√
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	√
Generalisability	21	Discuss the generalisability (external validity) of the study results	√
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	√

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.