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Validity and Reliability of Chinese Physical Activity Questionnaire for Children aged 10-17 years*

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Abstract

Objective This study is aimed to report the development, the reliability and validity of the Chinese Children Physical Activity Questionnaire (CCPAQ) which was designed to assess physical activity pattern in young population.

Methods The CCPAQ was administered two times in 119 children (mean age years 13.1, *s* 2.4; boys 47%) to examine reliability by using intraclass correlation coefficients. Validity was determined in 106 participants by agreement with the CCPAQ measures and the objective method, the ActiGraph accelerometer. Data on physical activity pattern including time spent in different intensities and total physical activity, sedentary behavior as well as physical activity energy expenditure were used to assess the validity with Spearman's correlation coefficient and the Bland-Altman plots.

Results The reliability of the CCPAQ ranged from 0.63-0.93 (Intraclass correlation coefficient). Spearman's correlation coefficient for validity of time spent in total physical activity and sedentary behavior both were 0.32 (P<0.001), and for physical activity energy expenditure was 0.58 (P<0.001). Time spent in moderate-to-vigorous physical activity and light physical activity showed a relatively low correlation with the accelerometer (*rho*=0.20, P=0.040; *rho*=0.19, P=0.054).

Conclusions The CCPAQ appears promising as a feasible methodology to assess physical activity pattern in Chinese children.

Keywords: Physical activity; Sedentary behavior; Child; Questionnaire; Validity and reliability

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INTRODCUTION

Physical activity is important for physical, psychological and cognitive health in children[1]. Systematic reviews reinforce global public health concerns that physical inactivity and sedentary behavior are associated with adiposity, cardiovascular disease, cognitive decline and social behavioral problems [2, 3]. Recent findings suggested that there are likely to be synergistic health benefits by obtaining optimal combinations of movement behaviors (e.g. high physical activity, low sedentary behavior and high sleep) [4, 5]. With more than 316 million children and adolescent classified as overweight or obese globally[6], strategies for increasing daily physical activity and minimizing time spent sedentary, and promote positive lifestyle behaviors that will track into adulthood, is a public health priority.

Physical activity pattern is a multi-dimensional construct and represents the combined effects of the frequency, intensity, time, type and context of physical activity and sedentary behavior. Recent literature suggests that the description of physical activity should be reframed as a pattern comprising multiple domains, dimensions, or correlates[7]. For children, the nature of physical behaviors (such as short and intermittent bouts of activities), the characteristics of patterns (such as various types of activities) and their cognitive capacity (such as difficulty in performing detail) make it challenging to measure physical activity pattern[8].

Accurate physical activity surveillance measures are essential for public health research, policy and practice[9]. Technological developments have produced a variety of devices such as pedometers, multi-sensors, and smart watches that assess human physical activity effectively[10]. However, they provide less information on the type of activity behaviors or where and in what context the physical activity was performed, which is critical for understanding the underlying modifiable factors promoting behaviors. In addition, self-report methods might be more feasible to estimate physical activity level in large surveys due to their cost effective and easy distribution. Questionnaires are important in assessing the mode and domain of physical activity that are not available to be measured objectively, and make physical activity pattern assessment possible [11, 12]. In order to maximize utility questionnaires need to fit the needs of the country in which they are based.

Numerous physical activity questionnaires have been developed especially for Caucasian youth, with variation in measurement protocol, physical activity dimensions assessed, recall period and other aspects[13]. A paucity of studies applied the commonly used physical activity questionnaires into the Chinses counterparts and found that the translation of available questionnaires performed less well in Chinese youth[14, 15]. It is noticeable, reliable and validated physical activity questionnaire for use in Chinese young population are limited[16]. This is a major omission from the literature as China is currently under-going an extensive economic development and rapid urbanization. As such, there is a growing need to develop a new questionnaire for Chinese children in assessing physical activity patterns across a whole day, providing the basis for children's 24-hour movement measurement and its related health effect research. Understanding how it changes as a result of development is a research gap that urgently needs to be addressed.

The Chinese Children Physical Activity Questionnaire (CCPAQ) was designed to address the full complements of physical activity pattern across 24-hour period and provide the estimation of physical activity energy expenditure in Chinese children. The aims of the current study were to report on the development of the CCPAQ and to evaluate its validity as well as the test-re-test reliability in children aged 10-17 years.

METHODS

Physical activity questionnaire

The CCPAQ was developed in five stages: 1) review of the literature to identify key elements of self-report measures; 2) assessment of reliability and validity study of the existing questionnaires; 3) designing the questionnaire format, content and flow; 4) consulting epidemiology, physical activity and other related fields experts and then revising the questionnaire; and 5) pilot testing.

The CCPAQ is a 7-day recall physical activity questionnaire for children and collects information on physical activity pattern comprising of 23 questions (see "CCPAQ Guide" in *Additional file 1*). It uses a time-based structure which has been used in other surveys such as the PAQ-C (Physical Activity for Older Children)[17] and a checklist of responses that is comparable to the SAPAC (Self-Administered Physical Activity Checklist) [18]. In CCPAQ activities are recalled sequentially across an entire day in the past week dividing into the weekday and the weekend. The codes table of children's physical activity types was made based on Chinese children's activity, which is a list of 32 activity codes in 3 categories. Physical activity pattern was evaluated by asking the students to select the kind of activities from the codes table, report the intensity of the physical activity according to the revised Rate of Perceived Exertion Scale for Exercise[19],and to best approximate the frequency and the amount of time spent in that activity last week. The energy expenditure of each activity was then estimated based on the latest Youth Compendium of Physical Activity (Activity Codes and Metabolic Intensity, 2017)[20]. Finally, the number of days per week that the students engaged in moderate-to-vigorous physical activity (MVPA) accumulated for at least 60 minutes a day was asked. The CCPAQ takes on average 12-15 minutes to complete.

Accelerometer data management

Physical activity was assessed using ActiGraph wGT3X-BT accelerometer (ActiGraph, LLC, Pensacola, Florida, USA) as the criterion method on the basis of its established reliability and accuracy [21]. For this study, the accelerometer was set to record data at a sampling rate of 30 Hertz. ActiGraph files were downloaded and then transformed into 10s epoch files in the commercial software (Acti life 13.3), using standard procedures for identifying non-wear time periods and interpolating gaps with missing data. The sleeping time of each individual was marked as non-wear time. The minimum wear-time for inclusion in the analysis was at least 8 hours per day for a minimum of 5 days (including at least 3 weekdays and 1 weekend). The reason is that 4-5 days and 8 hours daily of monitoring have been shown to achieve reliable activity data in a week[22].

The intensity of physical activity was defined using the cut points derived by Vanhelst et al.(2011)[23], with sedentary behavior below 400 counts/min, light physical activity (LPA) between 401 and 1900 counts/min, moderate physical activity (MPA) between 1901 and 3918 counts/min, vigorous physical activity (VPA) greater than 3919 counts/min. The Vanhelst et al. threshold were chosen for this study as it has been shown have good classification accuracy in Chinese children[24]. In addition, accelerometer-measured energy expenditure was calculated using the equation of Freedson VM3 Combination (2011)[25].

Sample and participants

In the spring and summer of 2018, 20 children in each grades 4, 7, 10 from schools (one elementary school and one middle school) in two districts were recruited by the Center for Disease Control and Prevention in China. The two districts are Yanqing District, Beijing city (the north of China) and Wanzhou District, Chongqing city (the south of China). The children were excluded from this study if they were taking medications or had medical illness affecting growth, injured or had other conditions limiting participation in physical activity, or had problems reducing adherence to the study protocol.

Participants were recruited through a brief presentation and instruction given during a parents meeting. The parents of all interested individuals received written and oral information. Written informed parental consent was obtained for all participants. The content and procedures of this study were designed according to the Helsinki Declaration and approved by National Institute of Nutrition and Health, Chinese Center for Disease Control and Prevention (Ethic committee approval code: 2013-018).

Study design

Participants' involvement was over 10 days as shown in Figure 1. Participants were asked to wear an ActiGraph accelerometer for 7 consecutive days during May in 2018. The participants received the accelerometer at the first visit and were required to engage in their normal activities. Participants were instructed to wear the accelerometer on the right side of the body at hip level. The wear time of the accelerometer was 24 hours (h) for 7 days. During the monitoring time period, investigators contacted the participants' parents by phone to remind of wearing and checking on compliance with the accelerometer, and to answer any questions about the study. Participants were advised to only remove the monitor for swimming or bathing and to keep a log in which they recorded non-wear time and reasons for removal. At the end of the 7-day monitoring period, the participants returned the accelerometer to school. In the meantime, the first-time CCPAQ questionnaire (CCPAQ 1) was administrated in the form of face-to-face interview by trained observers during a class. A day later, the participants were asked to complete the CCPAQ questionnaire (CCPAQ 2) again at school with data collected by the same interviewers. Anthropometric measures including height and weight using an electronic stadiometer (Hochoice, EF07) were collected from all participants. The COSMIN (COnsensus-based Standards for the selection of health status Measurement INstruments) Checklist was adopted as a guidance for the design of CCPAQ and the implementation of this study [26].

Statistical analysis

Descriptive analyses included calculating the median and standard deviation, quartiles or percentages for all variables. Univariate ANOVA procedures or χ^2 test were used to examine differences in the characteristic of the sample. The physical activity variables for the evaluation of reliability and validity of the CCPAQ were total time spent in physical activity, in sedentary behavior, and in two intensities levels namely MVPA and LPA, as well as physical activity energy expenditure. Statistical analyses were performed in SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

Reliability Analyses To examine reliability, the single measure, parametric interclass correlation coefficients (ICC) with 95% confidence intervals (CI) were calculated to evaluate the extent of agreement of CCPAQ in the test-retest analysis. A priori we assumed than an ICC≥0.70 would be indicative of acceptable reliability[27].

Validity Analyses Validity concerns two types of measurement properties in this study: content validity and construct validity. The content validity of the CCPAQ was assessed by consulting experts in the field of sports, nutrition and related areas. For construct validity, non-parametric Spearman's rank correlation coefficient (*rho*) was used to examine the correlations between minutes per day in each intensity level and physical activity energy expenditure as kilocalorie per day from the CCPAQ data and similar data from the accelerometer. The answers from CCPAQ 1 were used in the validity analyses. Based on the COSMIN checklist, *rho*≥0.50 is considered validity acceptable. The Bland and Altman method was used to provide an indication of the heteroscedasticity and the systematic random error of the data with 95% limits of agreement (mean difference ± 1.96 standard deviation) between the CCPAQ and the accelerometer. The variables used for the Bland and Altman analysis were physical activity energy expenditure, time spent in total physical activity, MVPA and sedentary behavior.

Sensitivity Analyses We recognize that there is debate within the field of accelerometer-measured physical activity on which intensity threshold to use[28]. To test the robustness of different cut-points of physical activity intensity for validity study, we made a number of sensitivity analyses repeating the main analyses based on other 3 different intensity thresholds (Evenson et al. cut-off[29], Puyan et al cut-off[30], Freedson et al cut-off[31]). The Evenson et al. (2008) cut-off has been widely used in Western country. Puyan et al cut-off (2002) is one of the highest intensity thresholds of physical activity, while Freedson et al (1998) has a low intensity threshold for MVPA. As these three thresholds were conducted with Western samples it is unclear whether they would be applicable for Chinese children.

RESULTS

Characteristics

120 participants were enrolled in the study. The final dataset included 119 participants (99% of sample) for the reliability analysis, 106 participants (88% of sample) for analysis of criterion validity (see "Flow diagram" in *Additional file 2*). Characteristics of the sample in reliability study and validity study stratified by sex are shown in Table 1.Boys spent more time in MVPA per day and more physical activity energy expenditure than girls. Physical activity energy expenditure and daily time spent in total physical activity, MVPA and sedentary behaviors were greater on weekday than on weekend (see *Additional file 3*).

Reliability

Reliability for time spent in total physical activity, MVPA, sedentary behavior and sleeping time ranged from 0.7 to 0.9, while a little lower for LPA and screen time (0.4 to 0.7) (Table 2). Overall, reliability was higher for physical behavior variables on weekday than on weekend. Similarly, reproducibility seemed to be higher for variables on boys than girls. The reliability for types of physical activity ranged from 0.57 to 0.88 (Table 3).

Validity

Content Validity The CCPAQ exhibits content validity as it provides information on the natural and intuitive of physical activity pattern, especially different intensity and types of physical activities as well as sedentary behaviors and sleep time across a whole day in the past week. Furthermore, the CCPAQ is capable of investigating other subset of activity, such as screen-based activities, activities in the school, out of school, households and during transportation.

Criterion Validity Physical activity energy expenditure displayed moderate validity on a week (*rho*=0.58, *P*<0.001) or on the weekday (*rho*=0.57, *P*<0.001). Correlations between the CCPAQ and the accelerometer tended to be higher for total time in physical activity and sedentary behaviors compared to correlations for MVPA and LPA. Stronger correlations were evident for boys than for girls, except daily time spent in MVPA and sedentary behavior during the weekend. Mean differences for time spent in all activity variables were negative that on average CCPAQ values were lower than accelerometer-measured values. There was no correlation between the two methods for the average days that accumulated a minimum of 60 minutes of MVPA in the last week (see Table 4).

Bland-Altman plots showed the degree of error in CCPAQ depended on the level of physical activity energy expenditure, MVPA or sedentary behaviors (Figure 2). Higher level of energy expenditure and MVPA were more likely to overestimate and the differences between both methods are much higher, whereas more time spent in sedentary behaviors was more likely to underestimate and the differences between both methods are much lower.

Sensitivity analyses

Using the cut-point of Evenson et al., similar validity correlations of physical activity variables between the CCPAQ and the accelerometer were found. Accelerometer data were re-categorized using 0-799 counts as the threshold for sedentary behavior in Puyan et al., and then the correlation was only 0.14 and insignificant (*P*=0.163). With the Freedson et al. cut-point, lower than the Vanhelst et al. cut point, there are no significant correlations in any physical activity variables (see Table 5).

DISCUSSION

This study demonstrates that estimates of daily physical activity energy expenditure, time spent in physical activity and sedentary behaviors from the CCPAQ in 10-to-17-year-old children are highly reliable and have moderate validity. Boys spent more time in high-intensity activities and had higher energy expenditure than girls in this study consistent with numerous investigations [32, 33]. Physical activity level tend to be higher on weekday than on weekend, similar to other study[34], which indicates that it will be more feasible for self-report instrument to separate a week into weekday and weekend to collect physical activity data.

The overall reliability of CCPAQ was in the strong range at 0.70 to 0.92. A systematic review illustrated that the median reliability correlation for newly developed questionnaires in youth was 0.68 (ICC) and for existing questionnaires was 0.64 (ICC) [35]. We found better agreement in CCPAQ than the average of other questionnaires. It is might due to the 1-day interval between the two administrations of CCPAQ, as previous studies examining questionnaire for measuring physical activity during the past week usually used a time interval of 1 day to 3 months. The CCPAQ can also provide the information on the types of physical activity and showed good reliability. Reproducibility was higher for in-school activity than sports/exercise outside school and household activity. Few studies have examined the reliability for the types of children's physical activity.

For physical activity energy expenditure and time spent in total physical activity, we found that the CCPAQ tended to be more reliable for boys and on weekday. A reliability study by Rangul et al.[37] found the WHO HBSC questionnaire more reliable for girls, and another study by Treuth et al. showed no sex differences [38]. The sex differences in our study might be due to that boys had a higher intensity of activity and spent more time engaged in competitive sports than girls and as such findings may be a function of the questions that were asked. High-intensity exercises tend to be more structured and memorable. The organized activity in physical education on weekday has also been found to be easier to recall and has higher repeatability than free-living activity on weekend.

Validity correlations between the CCPAQ and the accelerometer for time spent in total physical activity, energy expenditure and sedentary behaviors were generally moderate in magnitude (*rho*=0.32, *rho*=0.58 and *rho*=0.32). Systematic review evidence has shown that the median validity correlations of physical activity for youth was 0.22 (*rho*) and none of physical activity questionnaires for children show high validity [35]. The CCPAQ has been shown to be higher validity than other 7 day self-report questionnaires. One explanation that the CCPAQ differs from other questionnaires might be to set the recall period in a day sequence and clarify physical activity types into categories. However, using one question to compare behavior to physical activity guidelines of 60-minute MVPA per day in this study is likely to be inaccuracy. Conversely, Single-item Physical Activity Measure to this guidelines was found to have moderate validity (*rho*=0.44)[39]. Moreover, the CCPAQ seemed to be more valid for boys than girls, which is the same in terms of sex difference with SAPAC measure[18].

Previous validation study of PAQ-C in Chinese, on which informed the development of the CCPAQ suggested limited validity for MVPA when compared with accelerometer data (*rho*=0.24, *P*<0.01)[14]. This is similar to our results for time spent in MVPA (*rho*=0.20, *P*=0.040). Time spent in MVPA and LPA

showed lower agreement with accelerometer than total physical activity. This may due to a lack of consensus on homogenizing cut-off points when translating accelerometer intensity into physiologic intensity. The accelerometer cut points for the intensity of physical activity and sedentary behavior among children in the previous studies varied differently, leading to different estimates of activity intensity[28]. In this study we used an accelerometer threshold that was most appropriate for Chinese youth but it is broadly in agreement with other thresholds that have been used [40].As the threshold for when accelerometer data are used to indicate MVPA increases (i.e. a higher cut-point) the number of participants that underreported time spent in physical activity by CCPAQ declined but the validity correlation seemed to be lower. Using of the lowest cut points (Freedson et al)[41] would have resulted in overestimates of accumulated MVPA, which showed no criterion validity in the CCPAQ compared with the accelerometer. As such, it appears that the threshold used in this study provided a good approximation of physical activity in Chinese youth.

Bland-Altman analyses revealed relatively wide variation in limits of agreement, suggesting that the CCPAQ is more reliable for group physical activity estimates than individual investigations and therefore may be particular use as surveillance measure. Compared with the accelerometer data, we also found that the CCPAQ underestimated all the physical activity variables besides physical activity energy expenditure. The mean differences between the two measures were -78.0 min/day for total physical activity, -127.7 min/day for sedentary behavior, and 226.8 kcal/day for physical activity energy expenditure. These differences could be caused by recall bias, especially recalling in a whole day, which may influence the retrospective response. Unlike the other studies which over-report physical activity levels, our study seemed less likely to record the time spent in LPA. The amount of LPA that children participate in represents a very large and trivial fraction of their overall activity, which may be difficult to recall completely and limits the validity of subjective instrument.

Responses to the CCPAQ were compared by sex to determine if the measure captured sex-based differences in physical activity and if the reliability and validity differed by sex. Although sample size deceased due to the stratification analyses, recent study shows that 50 to 99 participants could provide stable agreement estimates between subjective and objective measurement of physical activity[42]. Besides, the response rate in this study was high (88% for validity study) and the general wear time of accelerometer was long due to the effective study management and implementation using the COSMIN checklist as a standardized tool for research. Thus, this study could provide support for investigating reliability and validity coefficient of the CCPAQ in different sex.

A feature of the CCPAQ is the integration of a compendium of energy costs designed for the specific types and intensity of physical activities in children. Since youth's basal metabolic rates decline gradually as they grow and become mature, the CCPAQ converts reported physical activity data to energy expenditure using determinate Metabolic Equivalent (METs) in different age groups. Previous studies examining the validity of energy costs in young people suggested limited validity when compared with accelerometer data [43, 44]. The higher correlation coefficients found in this study may be due to the use of youth-derived standard METs of specific activities. To our knowledge, this is the first study based on standardized METs reference in children to assess the validity of estimated physical activity energy expenditure from questionnaire against the accelerometer. Assessment of physical activity and estimation of its energy costs on a large scale has many implications for public health, applied research and clinical practice in young population.

The twice administrations of the CCPAQ were completed in reference to the same 7-day recall so that the differences between the two administrations only consist of reporting error with no variation

due to the real activity differences over time. However, the short time interval between two administrations in the reliability analyses is a potential limitation as it is possible that the participants may have a memory of their answers from the first administration. For measuring physical activity during the past week, a time interval of 1 day to two weeks may be considered appropriate and if more questions (e.g. more than 25 questions) and more difficult the questionnaires are, the time interval could be shorten[45]. It is also important to recognize that data were collected in two Chinese areas and the results may not generalize to other areas of China and other settings.

CONCLUSION

The CCPAQ is a unique questionnaire that was developed to focus on physical activity pattern and energy expenditure measurements across the whole day during last week for Chinese children. The CCPAQ has been found to be a reliable instrument that exhibits acceptable content and construct validity of physical activity pattern. It might be an easy and feasible instrument in children with the highlight of the importance of 24-hour movement behaviors and thus could be particular useful for large scale surveys and surveillance measures. This study provides insight into a surveillance method for physical activity pattern, filling the gaps in the developing country. Future research needs to focus on activity components and context to promote physical activity.

AUTHORS' CONTRIBUTIONS

All authors were involved in the conception of the review and the revision of the manuscript. Prof. ZHAO Wenhua directed all aspects of the study, including the design of the study protocol, administration of the research and interpretation of the results. Ms. YANG Xi contributed to the conception, design, acquisition, analysis and interpretation of data. Prof. JAGO Russell contributed intellectual input into the main ideas of this paper and assisted with writing of the manuscript. Dr. ZHAI Yi and Dr. YANG Zhenyu contributed to study design and assisted with writing of the manuscript. Dr. WANG Yuying and Ms. Si Xiang contributed to study design. WANG Jun, GAO Jianfen, CHEN Jingron and YU Yingjie coordinated the data-collection. All authors read and approved the final manuscript.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that they have no competing interests.

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Table 1. Participant characteristics by sex

	Reliability study				Validity study			
	Total	Boys	Girls	*P*	Total	Boys	Girls	*P*
Sample number	119/120 enrolled	56 (47%)	63 (53%)		106/120 enrolled	53 (50%)	53 (50%)	
Age[1]	13.1±2.4	13.3±2.5	13.0±2.4	0.590	13.1±2.5	13.3±2.5	12.8±2.4	0.279
Height(m) [1]	1.6±0.1	1.6±0.2	1.5±0.1	<0.001	1.6±0.1	1.6±0.2	1.5±0.1	<0.001
Weight(kg) [1]	50.2±16.4	55.7±19.0	45.4±11.9	0.001	50.1±16.9	56.0±19.2	44.2±11.5	<0.001
BMI (kg/m^2) [1]	20.1±4.2	21.0±5.1	19.3±3.1	0.036	20.1±4.4	21.1±5.2	19.2±3.2	0.023
Ethnicity [2]								
Majority	109 (91.6%)	52 (92.9%)	57 (90.5%)	0.448	98 (92.5%)	50 (94.3%)	48 (90.6%)	0.358
Minority	10 (8.4%)	4 (7.1%）	6 (9.5%)		8(7.5%)	3(5.7%)	5 (9.4%)	

Note. BMI=body mass index.

[1]descripted as Mean ± SD because of the normal distribution.

[2]descripted as absolute number (percentage) because of categorical data.

Table 2. Test-retest reliability of CCPAQ stratified by sex with the use of Intraclass Correlation Coefficient

	Median (25th percentile, 75th percentile)		Total (n=119)		Boys (n=56)		Girls (n=63)	
	CCPAQ 1	CCPAQ 2	ICC(95%CI)	*P*	ICC(95%CI)	*P*	ICC(95%CI)	*P*
PAEE(kcal/day)								
Week	598.5(427.6,799.7)	534.6(377.7,814.7)	0.93(0.89,0.95)	<0.001	0.93(0.88,0.96)	<0.001	0.90(0.85,0.94)	<0.001
Weekday	681.2(463.2,887.7)	590.0(447.0,912.5)	0.91(0.87,0.93)	<0.001	0.90(0.83,0.94)	<0.001	0.91(0.85,0.94)	<0.001
Weekend	396.3(220.2,627.2)	332.7(192.2,558.1)	0.82(0.74,0.88)	<0.001	0.89(0.81,0.93)	<0.001	0.70(0.53,0.81)	<0.001
Total PA(min/day)								
Week	63.0(42.5,90.7)	66.4(43.4,94.4)	0.82(0.74,0.87)	<0.001	0.85(0.76,0.91)	<0.001	0.76(0.64,0.85)	<0.001
Weekday	69.4(47.7,98.0)	72.1(46.5,100.8)	0.80(0.73,0.86)	<0.001	0.85(0.76,0.91)	<0.001	0.72(0.57,0.82)	<0.001
Weekend	40.3(17.3,90.0)	42.5(18.8,80.0)	0.70(0.60,0.78)	<0.001	0.64(0.46,0.77)	<0.001	0.77(0.64,0.85)	<0.001
MVPA(min/day)								
Week	27.5(11.6,54.4)	28.2(10.7,50.0)	0.79(0.71,0.85)	<0.001	0.85(0.76,0.91)	<0.001	0.70(0.55,0.81)	<0.001
Weekday	30.8(14.3,56.9)	29.0(12.0,53.8)	0.73(0.63,0.80)	<0.001	0.83(0.72,0.90)	<0.001	0.58(0.38,0.72)	<0.001
Weekend	6.75(0,46.3)	5.5(0,59.0)	0.79(0.71,0.85)	<0.001	0.75(0.61,0.85)	<0.001	0.85(0.76,0.91)	<0.001
LPA(min/day)								
Week	29.6(18.1,49.1)	31.4(17.6,51.8)	0.63(0.51,0.73)	<0.001	0.57(0.37,073)	<0.001	0.69(0.54,0.80)	<0.001
Weekday	33.7(18.8,55.2)	37.5(17.1,60.0)	0.64(0.52,0.73)	<0.001	0.62(0.43,0.76)	<0.001	0.65(0.48,0.77)	<0.001
Weekend	15.3(5.0,35.0)	18.0(5.0,37.0)	0.43(0.27,0.56)	<0.001	0.55(0.35,0.70)	0.041	0.55(0.35,0.70)	<0.001

Note. CCPAQ=Chinese Children's Physical Activity Questionnaire; CCPAQ 1=the first-time CCPAQ questionnaire investigation; CCPAQ 2=the second-time CCPAQ questionnaire investigation; ICC=Intraclass Correlation Coefficients; PA=Physical Activity; PAEE=Physical Activity Energy Expenditure; MVPA=Moderate-to-Vigorous Physical Activity; LPA=Light Physical Activity.

Table 2. Test-retest reliability of CCPAQ stratified by sex with the use of Intraclass Correlation Coefficient (*continue*)

	Median (25^{th} percentile, 75^{th} percentile)		Total (n=119)		Boys (n=56)		Girls (n=63)	
	CCPAQ 1	CCPAQ 2	ICC(95%CI)	*P*	ICC(95%CI)	*P*	ICC(95%CI)	*P*
Sedentary behavior(min/day)								
Week	414.3(312.1,519.6)	390.0(289.6,472.9)	0.83(0.77,0.88)	<0.001	0.91(0.85,0.95)	<0.001	0.78(0.66,0.86)	<0.001
Weekday	467.0(355.0,552.0)	443.0(345.0,526.0)	0.85(0.79,0.89)	<0.001	0.88(0.80,0.93)	<0.001	0.83(0.74,0.90)	<0.001
Weekend	270.0(150.0,405.0)	251.3(133.8,337.5)	0.52(0.37,0.64)	<0.001	0.80(0.69,0.88)	<0.001	0.40(0.18,0.59)	<0.001
Screen time(min/day)								
Week	32.1(13.5,68.6)	25.7(10.0,57.1)	0.65(0.53,0.74)	<0.001	0.78(0.66,0.87)	<0.001	0.56(0.37,0.71)	<0.001
Weekday	10.0(0,36.0)	8.5(0,30.0)	0.69(0.58,0.77)	<0.001	0.69(0.53,0.84)	<0.001	0.68(0.52,0.80)	<0.001
Weekend	75.0(30.0,120.0)	60.0(22.5,120)	0.47(0.32,0.60)	<0.001	0.74(0.60,0.84)	<0.001	0.27(0.30,0.48)	0.016
Sleeping time(min/day)								
Week	520.0(460.0,570.0)	513.8(467.5,570.0)	0.86(0.81,0.90)	<0.001	0.94(0.91,0.97)	<0.001	0.80(0.68,0.87)	<0.001
Weekday	480.0(410.0,540.0)	480.0(405.0,540.0)	0.89(0.85,0.92)	<0.001	0.91(0.86,0.95)	<0.001	0.87(0.79,0.92)	<0.001
Weekend	560.0(480.0,600.0)	570.0(480.0,630.0)	0.70(0.59,0.77)	<0.001	0.88(0.81,0.93)	<0.001	0.57(0.37,0.71)	<0.001
Number of days spent time in MVPA≥60min	1.8±1.8	1.6±1.7	0.86(0.80,0.90)	<0.001	0.84(0.73,0.90)		0.89(0.83,0.94)	<0.001

Note. CCPAQ=Chinese Children's Physical Activity Questionnaire; CCPAQ 1=the first-time CCPAQ questionnaire investigation; CCPAQ 2=the second-time CCPAQ questionnaire investigation; ICC=Intraclass Correlation Coefficients; PA=Physical Activity; PAEE=Physical Activity Energy Expenditure; MVPA=Moderate-to-Vigorous Physical Activity; LPA=Light Physical Activity.

Table 3. Test-retest reliability of different types of physical activity by CCPAQ with the use of Intraclass Correlation Coefficients

	Total（n=119）				Boys（n=56）				Girls (n=63)			
	Median (25^{th} percentile, 75^{th} percentile)		ICC(95%CI)	*P*	Median (25^{th} percentile, 75^{th} percentile)		ICC(95%CI)	*P*	Median (25^{th} percentile, 75^{th} percentile)		ICC(95%CI)	*P*
	CCPAQ 1	CCPAQ 2			CCPAQ 1	CCPAQ 2			CCPAQ 1	CCPAQ 2		
Transportation												
PAEE	38.3(4.3,86.7)	40.5(6.6,96.3)	0.73(0.63,0.80)	<0.001	41.2(3.9,97.5)	40.9(0.0,142.4)	0.70(0.54,0.81)	<0.001	33.7(4.3,79.1)	33.8(8.6,81.1)	0.79(0.68,0.87)	<0.001
TPA	20.0(9.2,33.8)	23.6(11.4,35.7)	0.65(0.54,0.75)	<0.001	21.1(10.0,35.4)	26.8(14.3,35.7)	0.57(0.36,0.72)	<0.001	20.0(8.6,31.5)	21.4(10.7,34.6)	0.70(0.55,0.81)	<0.001
Activity in School												
PAEE	90.5(51.2,162.9)	79.3(44.8,167.1)	0.84(0.78,0.89)	<0.001	106.8(62.2,183.8)	87.8(50.2,193.6)	0.82(0.71,0.89)	<0.001	83.7(40.0,155.6)	77.9(37.6,122.1)	0.86(0.77,0.91)	<0.001
TPA	23.9(13.6,36.6)	24.6(11.9,35.9)	0.86(0.80,0.90)	<0.001	24.9(13.4,36.5)	24.8(11.4,38.5)	0.88(0.81,0.93)	<0.001	23.0(13.6,37.1)	23.7(12.4,35.2)	0.80(0.69,0.87)	<0.001
Sports/exercise outside school												
PAEE	28.9(0.0,93.5)	13.2(0.0,71.5)	0.75(0.66,0.82)	<0.001	49.0(0.0,142.4)	32.1(0.0,99.9)	0.80(0.68,0.88)	<0.001	15.2(0.0,51.9)	7.4(0.0,37.6)	0.61(0.43,0.74)	<0.001
TPA	9.6(0.0,28.6)	7.1(0.0,23.0)	0.73(0.63,0.80)	<0.001	16.1(0.2,35.7)	10.0(0.0,28.3)	0.76(0.63,0.85)	<0.001	6.0(0.0,22.5)	4.3(0.0,17.7)	0.70(0.55,0.81)	<0.001
Household												
PAEE	3.0(0.0,11.0)	3.0(0.0,10.9)	0.70(0.60,0.78)	<0.001	5.3(0.0,16.2)	5.4(0.0,19.4)	0.70(0.53,0.81)	<0.001	1.7(0.0,9.1)	2.0(0.0,7.0)	0.68(0.52,0.79)	<0.001
TPA	2.9(0.0,7.1)	2.9(0.0,8.6)	0.84(0.77,0.88)	<0.001	3.2(0.4,7.1)	3.2(0.89,8.6)	0.86(0.78,0.92)	<0.001	2.9(0.0,7.5)	2.9(0.0,8.6)	0.80(0.69,0.88)	<0.001

Note. CCPAQ= Chinese Children's Physical Activity Questionnaire; CCPAQ 1=the first-time CCPAQ questionnaire investigation; CCPAQ 2=the second-time CCPAQ questionnaire investigation; ICC=Intraclass Correlation Coefficients; CI=Confidence Interval; TPA=Total physical activity (Unit: minutes/day); PAEE=physical activity energy expenditure (Unit: kcal/day).

Table 4. Validity coefficients for movement behaviors and energy expenditure comparing the CCPAQ and accelerometer measurement

	Spearman's correlation coefficient (*P* value)			Comparison between two measures			
	Total（n=106）	Boys（n=53）	Girls（n=53）	Mean±SD	No. over	No.under	No.same
PA energy expenditure(kcal/day)							
Week	0.58(<0.001)	0.57(<0.001)	0.55(<0.001)	226.8±254.8	82	23	1
Weekday	0.57(<0.001)	0.58(<0.001)	0.45(<0.001)	315.3±303.2	96	10	0
Weekend	0.12(0.217)	0.08(0.601)	0.10(0.504)	139.3±396.1	65	41	0
Total PA(min/day)							
Week	0.32(<0.001)	0.39(0.004)	0.27(0.047)	-78.0±58.1	10	96	0
Weekday	0.34(<0.001)	0.38(0.005)	0.29(0.031)	-71.7±56.9	13	93	0
Weekend	0.22(0.021)	0.22(0.116)	0.22(0.107)	-79.2±81.5	15	91	0
MVPA(min/day)							
Week	0.20(0.040)	0.24(0.085)	0.14(0.330)	-19.4±36.4	26	80	0
Weekday	0.26(0.007)	0.28(0.046)	0.24(0.079)	-18.2±36.3	25	78	3
Weekend	0.23(0.017)	0.09(0.521)	0.34(0.011)	-17.6±45.7	26	79	1
LPA(min/day)							
Week	0.19(0.054)	0.28(0.045)	0.10(0.469)	-58.6±43.9	8	98	0
Weekday	0.22(0.021)	0.28(0.047)	0.18(0.200)	-53.5±43.9	10	94	2
Weekend	-0.08(0.423)	0.09(0.503)	-0.23(0.100)	-61.7±63.6	12	93	1
Sedentary behavior(min/day)							
Week	0.32(<0.001)	0.26(0.060)	0.39(0.003)	-127.7±213.3	24	82	0
Weekday	0.32(0.001)	0.35(0.011)	0.30(0.030)	-120.6±248.5	23	83	0
Weekend	0.33(<0.001)	0.30(0.030)	0.35(0.009)	-154.9±331.2	25	81	0
Number of days spent time in MVPA ⩾60min	-0.15(0.130)	-0.29(0.041)	-0.04(0.789)	-2.8±2.9	18	78	10

Note. CCPAQ= Chinese Children's Physical Activity Questionnaire; PA=Physical Activity; MVPA=Moderate-to-Vigorous Physical Activity; LPA=Light Physical Activity

Mean±SD: Mean Difference between the CCPAQ and the accelerometer±Standard Deviation of Mean Difference. No. over: number of participants that over-estimated; No. under: number of participants that under-estimated; No. same: number of participants that reported the same as the accelerometer-measured values.

Table 5. Spearman's validity coefficients for physical activity variables comparing the CCPAQ and accelerometer

measurement using different cut points for physical activity intensity

Intensities of PA	Vanhelst et al.,2011			Evenson et al., 2008			Puyan et al., 2002			Freedson et al.,1998		
	Cut-points	*rho*	*P*	Cut-points	*rho*	*P*	Cut-points	*rho*	*P*	Cut-points	*rho*	*P*
Total activity	≥401	0.32	0.001	≥101	0.33	0.001	≥800	0.39	＜0.001	≥150	0.13	0.172
MVPA	≥1901	0.20	0.040	≥2096	0.24	0.016	≥3200	0.17	0.082	≥500	0.11	0.267
LPA	401-1900	0.19	0.054	101-2295	0.14	0.145	800-3199	0.20	0.043	150-499	0.15	0.043
Sedentary behavior	≤400	0.32	0.001	≤100	0.31	0.002	≤799	0.14	0.163	≤149	0.01	0.992

Note. CCPAQ=Children and Adolescents Movement Behaviors Questionnaire; PA=Physical Activity; MVPA=Moderate-to-Vigorous Physical Activity; VPA=Vigorous Physical Activity; MPA=Moderate Physical Activity; LPA=Light Physical Activity; rho=Spearman's correlation coefficient