


BMJ Open Effects of physical activity and sedentary behaviour on cardiometabolic risk factors and cognitive function in children: protocol for a cohort study

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ABSTRACT

Introduction Although studies showed that physical activity (PA) and sedentary behaviour (SB) were associated with cardiometabolic risk factors and cognitive function, both independent and combined associations among them are inconsistent. Cardiometabolic risk factors are also associated with cognitive function, but research of children is limited. Additionally, the brain level mechanisms have not been fully established. The proposed study aims to explore the associations and mechanisms of PA and SB on cognitive function and cardiometabolic risk factors in children.

Methods and analysis This is a school-based prospective cohort study. A total of 8324 participants of this study are primary school students aged 7–12 years old who are followed up every 2 years from January 2017 to December 2026. We used a stratified cluster random sampling to select five primary schools in Guangzhou, China. There are three phases at baseline. At phase I, we collect PA, SB and cognitive function by questionnaires and also conduct anthropometric and biochemical measurements in all participants. At phase II, PA, SB and cognitive function are measured respectively by accelerometers and cognitive tasks among participants randomly selected from four subgroups with different SB and PA levels. At phase III, event-related potentials are recorded using electroencephalogram during a cognitive task among participants randomly selected from phase II. We plan to follow-up all participants until they graduate from high school. The process applied at baseline and follow-up are approximately identical.

Ethics and dissemination Procedures described in this manuscript have been approved by the Ethical Review Committee for Biomedical Research, School of Public Health, Sun Yat-sen University (L2016-010). All parents or guardians of participants signed the informed consent form voluntarily before participating in the study. The findings of the study will be published in peer-reviewed journals.

Trial registration number NCT03582709

INTRODUCTION

Physical activity (PA) levels were declining and sedentary behaviour (SB) levels were rising among children in China in recent

Strengths and limitations of this study

- This is a prospective longitudinal study providing greater power to determine the effects of physical activity (PA) and sedentary behaviour (SB) on cardiometabolic risk factors and cognitive function over different development time points in children.
- We use a combination of subjective and objective measurements to provide quantitative and qualitative details from multiple dimensions.
- Samples were stratified into four subgroups with different PA and SB levels so that the independent and combined associations of SB and PA can be studied.
- It is not a representative sample because the registration is conducted among the schools in the specific area.

decades.¹ More than 80% of adolescents across the globe could not achieve the WHO's PA recommendation of 60 min/day.² About 65% children spend 2 hours/day or more on watching television, while over a third of children spend 3 hours/day or more on SB.³ Higher levels of moderate-to-vigorous physical activity (MVPA) can reduce the risk of cardiometabolic factors, regardless of the amount of time spent SB.^{4 5} However, SB is also suggested as an emerging and unique determinant of cardiometabolic diseases in children, independent of MVPA.⁶ Further studies are warranted to determine the independent and combined associations between PA and SB with cardiometabolic risk factors in children.

There is a growing number of studies investigating the associations of PA and SB on psychological consequences during development, especially on cognitive function in children. Meta-analyses showed a significant positive relationship between PA and cognitive function in children, such as executive

functions, attention and academic performance.^{7,8} Several physiological mechanisms including changes in vascularity⁹ and psychosocial mechanisms could explain the positive effects of PA on cognitive function. Conversely, previous study has shown a detrimental association between SB and cognitive function,¹⁰ but further studies suggested that different volume, pattern and forms of SB may have different impacts on cognitive development.^{11,12} The associations of SB and cognitive function are complex and the brain levels mechanisms also have not been fully established. Neurophysiological studies have revealed that physical activity influenced baseline electrocortical function and, thus, examination of electroencephalograms (EEGs) might provide evidence on brain level of cognitive operations.¹³

Cardiometabolic risk factors, including obesity,¹⁴ dyslipidaemia,¹⁵ altered glucose metabolism¹⁶ and hypertension¹⁷ were also associated with impaired cognitive function. The detrimental associations have been most fully demonstrated among adults.^{18,19} Meanwhile, the mechanism study showed that PA changes the vascularity and leads to increased oxygen saturation and glucose delivery, promotion of angiogenesis and improved cerebral blood flow to areas related to cognition, alertness and focus.⁹ We can speculate that cardiometabolic risk factors, influenced by SB or PA levels, or both, could have effects on cognitive function in children.

Given this partially unclear situation, the proposed study aims: (1) to evaluate the current situation of PA, SB, cardiometabolic risk factors and cognitive function with primary school students; (2) to clarify the independent and combined association of PA and SB with cardiometabolic risk factors and cognitive function and (3) to explore the brain levels mechanisms of PA and SB on cognitive function by EEG recordings.

Design

This study was designed as a school-based prospective cohort study. Primary school children aged 7–12 years were recruited and are followed up every 2 years from January 2017 to December 2026. There are three phases at baseline (figure 1).

Research strategies

Phase I: All students in school are investigated under an epidemiological survey from January 2017 to June 2017. Each student has his or her own identification to match their variable information. Questionnaire information (including an informed consent), biochemical outcomes and anthropometric data are collected. The questionnaire is distributed to children at school, and children and their parents fill it out together at home. Blood samples collection and anthropometric measures are conducted at school. Biochemical analysis is conducted at the laboratory of School of Public Health, Sun Yat-sen University or Health Promotion Center for Primary and Secondary Schools of Guangzhou Municipality. The current situation and the correlation among PA, SB, cardiometabolic risk factors and cognitive function will be analysed.

Phase II: To explore the further performance characteristics of children's cardiometabolic risk factors and cognitive function in different PA and SB levels, we classified participants into four subgroups (high PA/high SB, high PA/low SB, low PA/high SB, low PA/low SB). The detailed dimensions of PA and SB are measured more accurately by accelerometer combined with an activity log (PA-log), and cognitive function is measured more objectively through three paradigms. Cardiorespiratory fitness (CRF) and intelligence test are measured as covariates among the four subgroups. The assessments

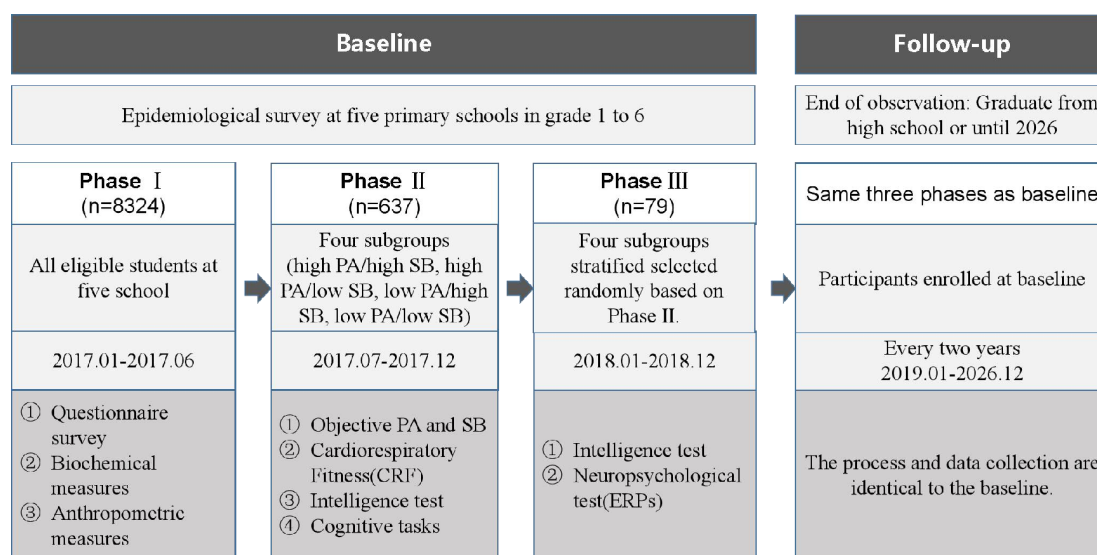


Figure 1 Design of the study.

High SB: SB \geq P75, low SB: SB $<$ P25, high PA: MVPA \geq 60 min/day, low PA: MVPA $<$ 150 min/week. CRF, cardiorespiratory fitness; ERP, event-related potential; MVPA, moderate-to-vigorous physical activity; PA, physical activity; SB, sedentary behaviour.

are conducted during break time or PA classes at school from July 2017 to December 2017.

Phase III: To explore the underlying neuropsychological mechanisms how do PA and SB impact cognitive function, four subgroups, selected randomly based on phase II are submitted to neuropsychological and electrophysiological assessments. EEG will be used to record event-related potentials (ERPs) for assessing brain level between four subgroups responses to cognitive tasks. Assessments are conducted at the laboratory of School of Public Health, Sun Yat-sen University from January 2018 to December 2018.

Sampling

Based on our previous studies, it is assumed that the rate of physical inactivity in children was about 49.2% in Guangzhou. The sample size of the cluster sampling should be increased by half, and the expected invalid response rate is 40%. In terms of stratification according to PA and SB, the calculations showed that a minimum of 3335 people were required. To guarantee that the heterogeneity of social background of the population was represented, a representation of the different school forms in Guangzhou was considered. Hence, the random sequence of schools was computer generated and stratified by school district and school size in each centre. A stratified cluster random sampling was used to select three central urban districts (Yuexiu District, Liwan District, Tianhe District) and two peripheral urban districts (Huangpu District, Panyu District), then respectively chose one ordinary primary school at random from the five districts. At last, we enrolled 8324 students to this cohort study, and the sample size met the requirements.

Participants were categorised into four groups using multiphase stratified probability sampling (figure 2). At first, SB \geq gender-specific, age-specific 75% percentile and $<$ gender-specific, age-specific 25% percentile were

assigned to the high and low SB subgroup, respectively. Second, based on the WHO standard, participants with MVPA ≥ 60 min/day were classified into high PA subgroup while those with MVPA < 150 min/week were classified into low PA subgroup. At last, about 640 children (160 students in each subgroup) were enrolled into the phase II. About 80 children (20 students in each subgroup adjusted for IQ, age, gender, body mass index (BMI), CRF) from phase II were enrolled into the phase III by stratified random sampling.

Inclusion and exclusion criteria

Phase I: Students are excluded if they had: (1) severe physical disease which may have adverse effects on daily physical activity; (2) a mental disease or medical condition leading to unavailability for the questionnaire and (3) severe medical condition that made them absent from school.

Phase II: Inclusion criteria: (1) 7–12 years old; (2) normal visual acuity; (3) right handed. Exclusion criteria: suspected to have developmental behaviour disorders according to the Strengths and Difficulties Questionnaire (SDQ).

Phase III: Children are considered if their IQ ≥ 80 identified by Wechsler Intelligence Scale for Children—Fourth Edition (WISC-IV). Other inclusion and exclusion criteria are consistent with the previous phases.

The characteristics of participants at baseline are presented in table 1.

MEASUREMENTS

Phase I

Multicomponents questionnaire survey

The questionnaire was validated in an earlier pilot study that showed acceptable reliability and validity (data not

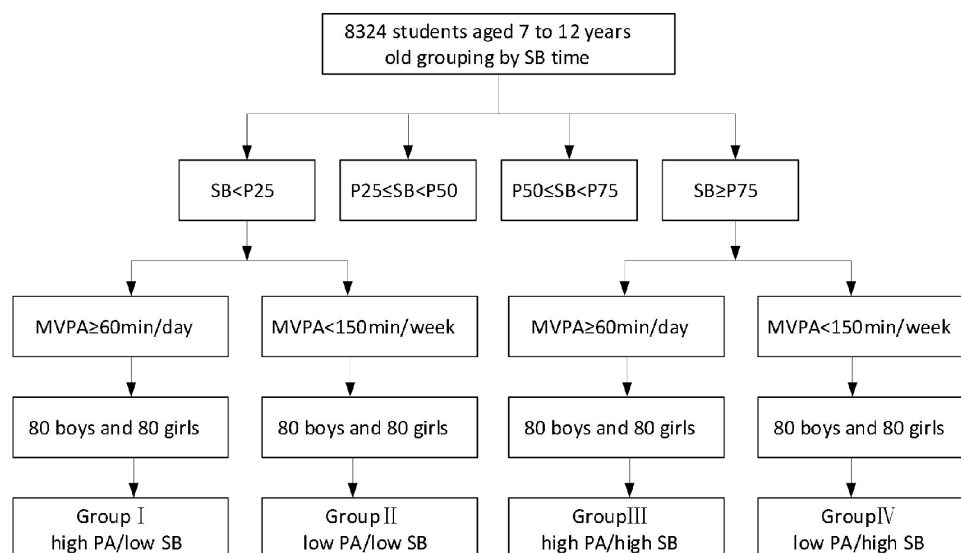


Figure 2 Sampling of phase II. High SB: SB $\geq P75$, low SB: SB $< P25$, high PA: MVPA ≥ 60 min/day, low PA: MVPA < 150 min/week. MVPA, moderate-to-vigorous physical activity; PA, physical activity; SB, sedentary behaviour.

Table 1 Baseline characteristics

	Phase I (n=8324)	Phase II (n=637)	Phase III (n=79)
Age (year)	9.1 (1.74)	9.19 (1.61)	8.09 (0.99)
Sex (boy)	4503 (54.1%)	328 (51.5%)	47 (59.5%)
Paternal educational level			
High school or below	2031 (24.4%)	160 (25.1%)	12 (15.2%)
Junior college	1923 (23.1%)	147 (23.1%)	21 (26.6%)
College or above	4378 (52.6%)	331 (51.9%)	46 (58.2%)
Maternal educational level			
High school or below	2247 (27.0%)	164 (25.8%)	19 (24.1%)
Junior college	2181 (26.2%)	162 (25.5%)	22 (27.8%)
College or above	3896 (46.8%)	310 (48.7%)	38 (48.1%)
Family income			
5000 or below	1748 (21.0%)	148 (23.3%)	20 (25.0%)
5000–12000	3579 (43.0%)	274 (43.0%)	30 (38.2%)
12000 or above	1723 (20.7%)	135 (21.2%)	18 (22.4%)
Not clear	1274 (15.3%)	80 (12.5%)	11 (14.5%)
VPA (min/day)	27.78 (32.48)	33.50 (39.32)	26.68 (31.49)
MPA (min/day)	31.75 (36.73)	38.96 (48.84)	29.79 (32.04)
MVPA (min/day)	59.44 (57.72)	72.46 (73.96)	56.47 (47.46)
Walking (min/day)	56.33 (71.27)	60.32 (70.15)	60.14 (55.67)
SB (min/day)	171.63 (86.05)	176.48 (110.76)	156.67 (86.56)
Homework time (min/day)	119.07 (60.23)	116.18 (72.77)	108.89 (65.53)
TV time (min/day)	31.40 (38.61)	35.51 (43.57)	31.87 (36.08)
Game time(min/day)	21.51 (32.30)	24.79 (38.63)	15.91 (22.85)
Bus time (min/day)	19.99 (27.50)	20.25 (28.41)	22.24 (39.56)

Data are n (%) or mean (SD).

MVPA, moderate-to-vigorous physical activity; PA, physical activity; SB, sedentary behaviour.

reported). The questionnaire is consisted of following three parts:

1. Questionnaire on the Health Monitoring of Primary School Students: A self-designed questionnaire is filled out by the children together with their parents for information on sociodemographic, early-life factors, family history, PA, SB, sleeping habits, dietary behaviour, mental health and other possible moderating variables of children. In this part, International Physical Activity Questionnaire Short Form is used to assess the frequency and duration of PA and SB.
2. The SDQ Chinese Version²⁰: To eliminate the children who is suspected to have developmental behaviour disorders, parents are asked to fill out this part.
3. Behaviour Rating Inventory of Executive Function Parent Form: It is an assessment of behaviour at home for children and adolescents aged 5–18 years, and the Chinese version was revised with good reliability and validity by Qian Ying in 2006.

Biochemical measurements

After 12 hours of overnight fast, fasting venous blood samples are taken and collected into EDTA vacuum tubes. Samples are separated within 2 hours of collection centrifuged at 3000r for 15 min, and plasma or serum are stored immediately at -80°C in the laboratory for future analyses. Five outcomes are measured: fasting glucose, triglyceride, total cholesterol, high-density lipoprotein and low-density lipoprotein. Fasting glucose is measured using the glucose oxidase method, and others are measured using radioimmunoassay kits at the departmental laboratory (HITACHI 7180 automated biochemistry analyser, Tokyo, Japan) at Health Promotion Center for Primary and Secondary Schools of Guangzhou Municipality. All samples are assayed in the same laboratory with the same analysers.

Anthropometric measurements

Anthropometric variables are measured by professional nurses and doctors according to standard procedures.

Height and weight are measured wearing light clothes and no shoes. Height is measured by a fixed stadiometer to the nearest millimetre. Weight is measured by a calibrated weighing scale to the nearest kilogram. BMI is calculated as weight (kg)/height (m).² BMI z-score is calculated based on WHO growth reference (2007).²¹ Waist circumference is measured directly on the body surface midway between the lower rib margin and the iliac crest. Additionally, the participants underwent measurement of body composition (Bioelectrical Impedance Analysis by InBody 720) who were drawn as a random sample. Systolic and diastolic blood pressures in the right arm are measured three times using validated electronic sphygmomanometer and a standard epidemiological method. The child is seated comfortably for at least 5 min prior to the first reading with 1 min between each measurement. Systolic blood pressure and diastolic blood pressure were recorded.

Phase II

PA and SB (accelerometer)

The ActiGraph GT3X accelerometer (ActiGraph, Pensacola, Florida, USA) is used to determine the cumulative time spent each day in activity at all intensity levels. Participants are instructed to wear the accelerometers all times during waking hours for seven consecutive days, except during water activities (such as swimming and showering) or sleeping. The accelerometers are attached to an elastic belt and worn above the iliac crest on the right side. Meanwhile, participants are asked to fill in a PA log-provided detailed information of PA and SB corresponding to the accelerometer records. Accelerometer data are analysed by software (ActiLife V.6.13.3). The following cut-off points²² for metabolic equivalent (METs) were used to define light-intensity, moderate-intensity and vigorous-intensity PA using the Actigraph accelerometer: sedentary: <1.5 MET (0–149 counts/min); light: 1.5≤MET <3 (150–499 counts/min); moderate: 3≤MET <6 (500–3999 counts/min); vigorous: ≥6 MET (400 or more counts/min). Total wear time was recorded and averaged per day. Data are analysed for participants who met the minimum wear time criteria (≥10 hours on ≥3 days).

Cognitive tasks

Corsi block-tapping task

Corsi block-tapping task is widely used as a representative of visuospatial attention and working memory. A traditional Corsi board structure shows nine yellow square frames on a black background. In the forward condition, participants tap the squares in the same serial order, from the first block that flashed to the last one. In case of a backward procedure, they are required to tap the blocks in a reverse serial order. Starting from sequences of two items, if at least one of these is repeated correctly, the next two trials of a sequence of an increased length will be administered. Participants' span is defined by the last sequence length that the participant repeats with one or

no errors before the task is terminated. Three accuracy measures are registered: the number of blocks of the longest correct sequence, the total number of correctly reproduced sequences and the product of these two measures.

Stroop task

The Stroop task is particularly useful for investigating attention control. We use three components with five colours in the experiment (red, green, blue, grey and purple). In the first part, the black word is the name of colour shown on the computer screen, and participants have to read out the meaning of the word. Next, the pattern @@@@ is served as a non-letter neutral stimulus, and participants have to identify the colour of ink. In the last part, participants are asked to mentally identify the same colour that is shown and to ignore the printed written words on the screen. Participants are instructed to respond as quickly and as accurately as possibly via the keyboard (buttons are marked with coloured stickers). Response accuracy and reaction time are collected to assess behavioural performance.

Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test is a commonly used measure of planning, organisation, cognitive shifting, goal-oriented behaviour and inhibition. The test consists of four stimulus cards, each with a different colour (red, green, blue and yellow), form (circle, triangle, cross and star) and number of shapes (one, two, three and four). Participants are administered 128 cards with various colours, forms and numbers of shapes on them and are required to match each of those cards with a stimulus card, according to which they consider correct. They are informed whether or not they are correct after each sort. The first sorting category is number, and after 10 consecutive correct sorts, the category changes to form, without forewarning, and then accordingly, to colour. There are several potential scoring measures, including categories completed, perseverative errors, non-perseverative errors and failure to maintain set.

Cardiorespiratory fitness

Fitness testing is undertaken on the participants using the multiphase 20 m shuttle run. We record the total laps and maximum run speed (MRS) completed as an indicator of his or her cardiorespiratory fitness. Estimations of maximal oxygen consumption (VO_{2max}) were obtained using Léger's equation ($VO_{2max} = 31.025 + 3.238 \times MRS - 3.248 \times \text{age} + 0.1536 \times MRS \times \text{age}$).²³

Combined Raven's Test

The intelligence of children is initially assessed using the Combined Raven's Test (second edition). Each participant is given a booklet and a sheet of answer paper in quiet classrooms by group testing. Participants are guided by trained research assistants and have 40 min to finish this test.

Phase III

Wechsler Intelligence Scale for Children—Fourth Edition

The WISC-IV is a psychometric measure of intelligence for children aged 6 to 16 years old, including four subscales of verbal comprehension, perceptual reasoning, working memory and processing speed. A validity study of the revision of WISC-IV Chinese version has been conducted by Zhang Houcan in 2009.²⁴

Event-related potentials

ERPs is a neuroimaging technique examining electroencephalographic activity used to identify structural and functional mechanisms,²⁵ and Go/Nogo paradigm have been used in previous studies indicating that the test can detect changes in inhibition and attentional control.²⁶ ERPs will be recorded through EEG during a Go/Nogo paradigm. Participants are instructed to respond by pressing a button contingent on the visual presentation of the letter 'M' on a computer screen, which appeared in 80% of the trials (Go condition). Conversely, participants are instructed to withhold the response when the letter 'W' is presented (Nogo condition, 20% of the trials). Overall 400 Go and Nogo cues are presented. A large percentage of false alarms, that is, pressing the response button upon presentation of the letter 'W', is presumed to indicate a reduced behavioural performance of inhibitory control. EEG is recorded with a sampling rate of 1000 Hz from 30 silver/silver chloride electrodes (FP1, FP2, F7, F3, FZ, F4, F8, FT7, FC3, FCZ, FC4, FT8, T7, C3, CZ, C4, T8, TP7, CP3, CPZ, CP4, TP8, P7, P3, PZ, P4, P8, O1, OZ, O2) using Brainamp amplifier (Brain Products, Gilching, Germany). In addition, vertical and horizontal electro-ocular activity are recorded by two additional pairs of electrodes. The software package VisionAnalyzer V.2.04 is used to analyse the data.

Follow-up and retention strategy

We will investigate same participants from the five primary schools at biennial follow-up. We plan to follow-up all participants until they graduate from high school. All three phases are performed in follow-up assessments and the process are identical to the baseline. Data collected from the cohort are summarised in [table 2](#).

To reduce the loss of follow-up, some incentives are provided. All schools completing the trial will be honoured as 'model schools' by School of Public Health, Sun Yat-sen University. The class teachers and school doctors involved receive some financial charges or gifts. All the students who participated in the blood sample collection have a free breakfast and some presents. In particular, we provide feedback to the participants and their parents about the results of all measurements.

Quality control

To evaluate the effectiveness of epidemiological methods and to find out possible problems, a pilot study was conducted among 298 students randomly selected from first to sixth grade for a preliminary investigation in April 2017. Before the commencement of full-scale study recruitment, all research assistants have been trained on the investigation purpose, plan, process, relevant knowledge and data collection skills. Then school doctors and head teachers attended a face-to-face appointment to discuss the study and trained by the professional members of the research team. On the other hand, appropriate help and guidance are given to parents through WeChat as effectively as possible. Data are recorded according to standardised methods and using calibrated instruments. About 5% students are rechecked randomly, it should be corrected if any problem is found, and all the students have to be measured again if the error exceeds 10%.

Table 2 Summary of the outcomes

	Measures	Details
Phase I (n=8324)	Questionnaire	1. Questionnaire on the Health Monitoring of Primary and Middle School Students 2. The Strengths and Difficulties Questionnaire 3. Behavior Rating Inventory of Executive Function Parent Form
	Biochemical measures	Fasting glucose, triglyceride, total cholesterol, high-density lipoprotein and low-density lipoprotein
	Anthropometric measures	Height, weight, body composition, waist circumference, systolic and diastolic blood pressures
Phase II (n=637)	Objective PA and SB	The ActiGraph GT3X accelerometers
	Cardiorespiratory fitness	Multistage 20 m shuttle run
	Intelligence test	Combined Raven's Test
	Cognitive tasks	1. Corsi block-tapping task 2. Stroop task 3. Wisconsin Card Sorting Test
Phase III (n=79)	Intelligence test	Wechsler Intelligence Scale for Children—Fourth Edition
	Neuropsychological mechanism	Investigated event-related potentials during Go/Nogo paradigm

Ethics and dissemination

All parents or guardians of participants signed the informed consent form voluntarily before taking part in the study. Participants' privacy is protected throughout the study process. The findings of the study will be published in peer-reviewed journals.

Patient and public involvement

We did not involve patients or the public in our work.

Statistical analyses

Questionnaires are entered twice to ensure the accuracy of the data recorded with EpiData V.3.1. Analyses are performed with statistical software SAS V.9.4 or SPSS V.21.0. To determine potential differences between those who attend the re-examinations and those who have been lost to follow-up, unplanned missing data are evaluated. Cross-sectional analyses at both baseline and follow-up are conducted. Differences between groups are determined by analysis of variance or χ^2 test. We plan to employ multiple linear regression models and multiple logistic regression models to examine the association of PA and SB with health-related variables, such as cognition, and cardiometabolic risk factors. Analyses also will involve isotemporal substitution models that examined the association of substituting 30 min (or some other length of time) each intensity category with an equal amount of time spent in the other intensity category. Further, the cohort study design allows various hypothesis to be tested longitudinally. Change analyses are considered whether changes in PA/SB are related to changes in outcomes.

DISCUSSION

Prevalence of sufficient PA among students in China from 2005 to 2018 was estimated as 31.1%.²⁷ The average time of SB was 2.92 hours/day from the data of 2010–2012 China National Nutrition and Health Surveillance.²⁸ Moreover, study found increasing trend in SB among Chinese schoolchildren.²⁹ It makes great sense to study PA and SB because China is suffering the burden caused by the transition of lifestyle and behaviour patterns among school-aged children.³⁰ SB is defined as any waking behaviour characterised by an energy expenditure ≤ 1.5 metabolic equivalents while in a sitting or reclining posture.³¹ Previous study showed that the potential role of SB in physical and mental health was different from either low levels PA or lack of PA.³² The independent and combined associations between PA and SB with health outcomes are far less clear. Is it right to emphasise increasing PA while ignoring SB or merely reducing SB? Therefore, we designed to stratify our samples into four subgroups with different SB and PA levels so that PA and SB can be studied independently, and combined associations also can be studied by coexposures. The best advice for children is what we are looking for.

Emerging evidence suggested that all intensities of PA (including light-intensity PA) were important and

different for health promotion and disease prevention.^{33 34} Meanwhile, different types of SB have different associations with cognitive function.³⁵ Previous studies paid more attention to the associations between MVPA or SB volume and cognitive performance,^{32 33} but the evidences of different forms or patterns are limited. In our study, PA and SB are measured using triaxial accelerometer for accurate and objective information of intensities and duration. In addition, we designed a PA-log to provide qualitative detail about the forms or patterns of PA and SB. What are the best varieties, intensities, frequencies and durations of PA and SB? Our research might be able to offer some suggestions.

The longitudinal study also will track cardiometabolic risk factors that provide strong evidence to determine the relationship between PA and SB on cardiometabolic risk factors. On the other hand, the study will explore the relationship between cardiometabolic risk factors and poor cognitive function. Progression of neurocognitive impairment is associated with increasingly severe manifestations of cardiovascular risk and disease in older adults.³⁶ Cardiovascular risk and disease have been less investigated as a potential predictor of cognitive health in children. Although cardiovascular diseases typically do not emerge before adulthood, an earlier sign of cardiovascular diseases, cardiometabolic risk factors, appeared to be related with cognitive function and can be reversed during the early life course.³⁷ Improved cardiometabolic risk profile may be one explanation how PA and SB affects on cognition and brain health.

What have to mention is that, since there were less studies addressed the potential neurophysiological features and mechanisms in children,³⁸ we planned to explore the brain levels mechanisms by investigating changes in ERPs which will be recorded using EEG during Go/Nogo paradigm. Neurophysiological studies have revealed differences in cognitive function that are related to PA behaviour. Examination of EEG has revealed that PA increased activation or higher mean frequency in spectral bands. P3 as a component of the ERPs, generated by a network of neural structures, is especially sensitive to changes in PA participation and aerobic fitness.¹³ Thus, using EEG to reflect changes in the brain can explore how PA and SB influence cognitive function.

Several strengths of this study are as follows. First, this study is a prospective design providing greater power to determine the varying effects of PA and SB. Second, we take into account normal children in various development phases which enable the researchers to investigate the changes in physical and neurobehavioural development among the distinct subgroups of exposed children. Then, we use a combination of subjective and objective measurements to provide quantitative and qualitative details from multiple dimensions.

An apparent weakness of this consortium is loss to follow-up. School-based setting is a valid option, which includes entire groups of children and adolescents, and provides an ideal and easily accessible environment which

can effectively reduce the loss of visits. The health Promotion Center for Primary and Secondary Schools of Guangzhou Municipality, a subordinate body of Education Bureau, has registered the information of all students in Guangzhou. The registers can be used to follow the participants and to evaluate potential differences between those who attend the re-examinations and those who have been lost to follow-up. Second, weather and climate may have an influence on PA. We conduct the questionnaire survey every time from March to May when the weather and climate conditions are relatively stable in Guangzhou to control these factors. Third, social development in Guangzhou is at a more advanced stage compared with some parts of China. Generalising findings from our study to the nation may be limited.

It is apparent that the available data can provide a greater understanding of the role of PA and SB in determining the development of cardiometabolic risk factors and cognitive function. The findings of this study may lead to more scientific and effective early treatment and primary prevention strategies on PA and SB in schools.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Procedures described in this manuscript have been approved by the Ethical Review Committee for Biomedical Research, School of Public Health, Sun Yat-sen University (L2016-010).

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