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Original Article

A transtheoretical model-based analysis of sedentary behaviors in Chinese high school students

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Abstract: This study aimed to investigate sedentary behaviors and relevant correlates in Chinese high school students. A total of 3,422 students (aged 11-19 years) were surveyed regarding psychological factors towards sedentary behavior. Analyses of variance (ANOVAs) were performed to examine the effects of sedentary time, processes of change, self-efficacy, and decision balance regarding the sedentary behavior stage. A logistic regression analysis was used to examine the relationships between sedentary behavior and sex, grade, stages of change, and transtheoretical model (TTM) constructs. The findings indicated that high school students were significantly more sedentary on weekdays than on weekends, boys exhibited significantly less sedentary time than girls, and sedentary time was significantly greater in junior high school students than in senior high school students. Differences across the stages of change were identified in sedentary time, processes of change, decision balance, and self-efficacy. Furthermore, logistic regression analysis indicated that sex, grade, and TTM constructs, such as processes of change and decision balance, were associated with sedentary behaviors. These novel findings in Chinese high school students suggest tailored health education and practical interventions should be adopted to reduce sedentary time and thereby improve the efficacy of health promotion.

Keywords: Transtheoretical model (TTM), stages of change, sedentary behaviors, high school students

Introduction

Sedentary behavior has increasingly been recognized as an important area of study in health research. The most common definition of sedentary behaviors includes a range of tasks with an energy expenditure less than 1.5 times the resting energy expenditure; these behaviors include television viewing, reading, working with computers, or talking with friends on the phone while sitting [1]. Sedentary behaviors are associated with poor health outcomes, such as type 2 diabetes [2], cardiovascular disease [2, 3], metabolic syndrome [4], weight gain, and obesity [5-8]. The prevalence of sedentary behaviors in young individuals has increased; specifically, children and youth spend the majority of their discretionary time engaging in sedentary pursuits (e.g., watching television or playing video games) [9-11]. For example, Canadian children and youth spend an average of 8.6 hours per day or 62% of their waking hours sedentary [12]. Similar trends have been reported in the United States (U.S.) where children and adolescents spend an average of 6-8 hours per day sedentary [13-15]. In China, youth are under greater stress to perform well in school and typically have heavy homework loads [16]; thus, they must spend more hours engaged in sedentary activities. The Sixth National Youth Physical Fitness and Health Survey of China indicated that the amount of time spent sedentary is increasing in high school students aged 11-22 years [17]. A survey in Jiangsu Province of China demonstrated that adolescents aged 12-14 years spend 10.8 hours per day studying in school and at home [18]. Furthermore, once individuals lead a sedentary lifestyle during childhood, sedentary behaviors continue during adulthood, which may have negative impacts on health.

To develop effective intervention strategies that aim to decrease sedentary time, the determinants of sedentary behaviors should be identified. Current theoretical frameworks hypothesize that a complex interplay between personal circumstances and environmental and social factors determine sedentary behavior [19, 20]. Demographic and health variables of interest regarding sedentary behaviors include sex, age, level of educational attainment, income, weight, and exercise-related self-efficacy [21, 22]. Micklesfield et al. investigated the association between socio-ecological factors (e.g., individual, maternal, household, and community) and time spent engaged in sedentary behavior in a sample of young adolescents [23]. Furthermore, support from family members and friends is also a significant factor [24].

One of the most popular models used to investigate behavioral determinants and inform interventions is the transtheoretical model of behavior change (TTM) [25, 26]. The TTM defines five discrete stages of change (i.e., precontemplation, contemplation, preparation, action, and maintenance), which discriminate individuals based on current behaviors and the intention to change behaviors. In the pre-contemplation stage, individuals are not motivated to change their unhealthy behavior within the next 6 months, whereas the maintenance stage reflects individuals who have engaged in healthy behaviors for longer than 6 months. According to the TTM, individuals can progress and regress from one stage to another stage. Specific TTM components, such as decisional balance or self-efficacy, should be applied in interventions to facilitate movement to subsequent stages of change. Decisional balance refers to an individual's relative weighing of the pros and cons [27, 28]. The TTM hypothesizes that to progress from the pre-contemplation stage, the pros of changing must increase. To progress from the contemplation stage, the cons of changing must decrease. Self-efficacy reflects the situation-specific confidence that individuals have in their ability to cope with high-risk situations without relapsing. The TTM assumes that self-efficacy monotonically increases from pre-contemplation to maintenance [29]. Therefore, attention should focus on the decision-making ability and psychological factors that influence an individual's behavior change, rather than the behavior itself [30]. The TTM uses the concepts of stages and processes of change in a format that enables the design of relevant interventions to facilitate behavior change in target populations [31]. For example, this model can be used to predict addictive behavior and exercise adherence. The TTM is used to categorize individuals into different stages with different processes used to transition individuals to the next stage. It is therefore important to identify the individual's current stage and subsequently utilize stage-specific strategies known to be effective for each stage [32, 33]. The TTM model has been successfully used to guide exercise behaviors in the U.S. and Europe and has exhibited a high predictive power for self-reported physical activity in some studies [31, 34, 35].

To the best of our knowledge, no study has assessed the stages of sedentary behavior in Chinese high school students. Therefore, in this study, we applied the TTM in a sample of Chinese high school students, and our results provide a scientific basis for health promotion and behavior change interventions.

Materials and methods

Participants and procedure

The data were collected from June to October 2012. According to the characteristics of China's geographical distribution, three cities, namely, Hangzhou, Wuhan, and Xi'an, were selected to represent the eastern, middle, and western regions, respectively. Using a stratified cluster sampling method, one junior high school with more than 2,000 students (ages 11-15 years) and one senior high school with more than 1,500 students (ages 14-19 years) in downtown areas were selected as the sample. Twelve high schools were selected from these three cities, including six junior high schools and six senior high schools. In each school, 300 students were randomly selected as the participants. Ethical approval was obtained from the provincial education department, and the participants provided written informed consent prior to participation in the study. Three thousand six hundred students aged 11-19 years were surveyed. In total, 3,422 students (male n = 1794, female n = 1628, mean age 14.9 years, standard deviation [SD] = 1.67) completed the survey questionnaire (95.1% response rate); the remaining 178 students

(4.9%) were classified as missing data. The numbers of participants from Hangzhou, Wuhan, and Xi'an were 1,135, 1,051, and 1,236, respectively; 1,973 (57.66%) students were in junior high school and 1,449 students (42.34%) were in senior high school.

Instruments, processes of translation, and validation of measures

This study comprised a cross-sectional survey. The quantitative data were collected with a standardized self-report questionnaire, which examined the sedentary behavior of high school students and the TTM constructs related to sedentary behavior. To assess sedentary behavior [36], the Adolescent Psychosocial scales/Sedentary behavior developed by Norman and colleagues was used, which has been broadly implemented across populations. The questionnaire was translated into Chinese by a committee using a back-translation method. Two bilingual investigators translated the instruments from English to Chinese. Following the translation, two additional bicultural/bilingual investigators back-translated the Chinese instruments to English. To adapt the instrument to the Chinese culture, the Chinese version was subsequently evaluated and modified to be culturally equivalent. Finally, the instruments were reviewed by two Chinese scholars who are familiar with exercise behavior, and they provided feedback regarding the word editing. The good reliability and validity of the preliminary version of the measure has been established [37].

There were six aspects of measurement in this study: demographic characteristics, sedentary time, stages of change, change strategies, decision balance, and self-efficacy of high school students.

Sedentary time measure: Sedentary time was defined as the time spent engaging in the following sedentary behaviors: watching TV/videos, reading, writing, drawing, building blocks, listening to the radio, and playing with sedentary games, toy vehicles, puppets, or board games. It excluded school-related sedentary behaviors, such as time spent in school, doing homework, and reading [1, 38]. Doing homework during non-learning time (i.e., a non-school day) was also regarded as a type of sedentary behavior [38]. At the beginning of the questionnaire, the definition and scope of sedentary behaviors were explained to the participants, and they were subsequently asked "On a school day/non-school day, how many hours do you usually spend on sedentary behavior generally?" (A: 0 h; B: 1 h; C: 2 h; D: 3 h; E: 4 h; F: 5 h; G: ≥ 6 h). These two items determined the participants' sedentary time on weekdays and weekends, which reflected the prevalence of sedentary behavior.

We dichotomized the sedentary time on weekdays into (0) ≤ 5 hours and (1) > 6 hours and the sedentary time on weekends into (0) ≤ 4 hours and (1) > 5 hours [39]. Based on the recommendations from Healthy People 2010 and the American Academy of Pediatrics, which suggest individuals should watch < 2 hours of TV viewing per day, [41] we set the cut-off point as 5 hours per day on weekdays or 4 hours per day on weekends when considering other types of sedentary behavior. This cut-off point was also the median split for the sample.

Stage of change measure: The action stage for sedentary behaviors was defined as "less than 2 hours per day spent on sedentary behavior". After the participants' general sedentary behavior time was assessed, they were asked "Do you always continuously sit less than 2 hours per day?" The participants were asked this second question to understand their stages of change for engaging in less sedentary behaviors [40]. A response of "No, and I do not intend to in the next 6 months" was classified as the pre-contemplation stage. A response of "No, but I do not intend to in the next 6 months" was classified as the contemplator stage. A response of "No, but I do not intend to in the next 30 days" was classified as the preparation stage. A response of "Yes, and this habit has been formed in the last 6 months" indicated the action stage, whereas a response of "Yes, and this habit has been maintained for more than 6 months" indicated the maintenance stage. In addition, 2-week test-retest reliability measures were conducted to assess instrument stability in 180 students from the main sample population, and the reliability coefficient was calculated to be 0.83.

Processes of change measure: Processes of change comprise overt and covert activities that individuals use to modify their behaviors [26]. The processes are grouped into two high-

Table 1. Participant stage distribution

Variable	Pr	C	P	A	M	X^2	P
Sex							
Males	504 (28.1)	364 (20.3)	318 (17.7)	188 (10.5)	420 (23.4)	17.45	0.002
Females	463 (28.4)	371 (22.8)	337 (20.7)	128 (7.9)	329 (20.2)		
Grade							
Junior high school	510 (25.8)	452 (22.9)	409 (20.7)	226 (11.5)	376 (19.1)	81.11	< 0.001
Senior high school	457 (28.3)	283 (19.5)	246 (19.5)	90 (6.2)	373 (25.7)		
Total	967 (28.3)	735 (21.5)	655 (19.1)	316 (9.2)	749 (21.9)		

Note: Pr = Pre-contemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance. *Data represent the number (percentage).

Table 2. Means and standard deviations of the sedentary times across five stages of change in Chinese high school students

Variable	PC (n = 967)	C (n = 735)	P (n = 655)	A (n = 316)	M (n = 749)	P, h^2	Tukey's HSD[a]
Weekdays							
Total	4.71 ± 1.85	4.40 ± 1.83	4.12 ± 1.91	3.20 ± 1.98	4.06 ± 2.23	< 0.001, 0.044	Pr > C > P > A, A < M
Sex							
Males	4.51 ± 1.93	4.24 ± 1.85	4.01 ± 1.97	3.28 ± 1.97	3.97 ± 2.23	< 0.001, 0.031	Pr > C > P > A, A < M
Females	4.92 ± 1.73	4.57 ± 1.80	4.21 ± 1.85	3.07 ± 1.99	4.17 ± 2.23	< 0.001, 0.062	Pr > C > P > A, A < M
Grade							
Junior high school	4.56 ± 1.78	4.44 ± 1.72	4.07 ± 1.77	3.15 ± 1.83	4.07 ± 2.09	< 0.001, 0.050	Pr, C > P > A, A < M
Senior high school	4.87 ± 1.91	4.35 ± 1.99	4.19 ± 2.11	3.29 ± 2.32	4.06 ± 2.36	< 0.001, 0.039	Pr > C, P > A, A < M
Weekends							
Total	4.57 ± 1.61	4.24 ± 1.58	3.86 ± 1.56	3.42 ± 1.58	3.92 ± 1.81	< 0.001, 0.045	Pr > C > P > A, A < M
Sex							
Males	4.57 ± 1.63	4.08 ± 1.61	3.75 ± 1.61	3.42 ± 1.67	3.88 ± 1.83	< 0.001, 0.047	Pr > C, P > A, A < M
Females	4.57 ± 1.59	4.39 ± 1.54	3.97 ± 1.54	3.41 ± 1.44	3.97 ± 1.78	< 0.001, 0.044	Pr, C > P > A, A < M
Grade							
Junior high school	4.38 ± 1.66	4.20 ± 1.58	3.77 ± 1.51	3.26 ± 1.53	3.70 ± 1.81	< 0.001, 0.049	Pr, C > P > A, A < M
Senior high school	4.78 ± 1.53	4.29 ± 1.59	4.02 ± 1.63	3.81 ± 1.65	4.14 ± 1.79	< 0.001, 0.038	Pr > C, P > A, A < M

Note: Pr = Pre-contemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance. [a]Mean differences for the Tukey's HSD pairwise comparisons ($P < 0.05$).

order factors that represent cognitive (i.e., increased consciousness, dramatic relief, self-reevaluation, environmental reevaluation, and self-liberation) and behavioral (i.e., social liberation, counter-conditioning, stimulus control, reinforcement management, and helping relationships) processes. This construct was used to reflect adolescent thoughts and behaviors during an action time and their feelings while making decisions. A factor analysis was performed to generate a factor correlation matrix of the revised questionnaire. The items with factor loadings less than 0.50 were deleted from the original questionnaire, and 15 items were ultimately used in this study to assess the processes of change related to sedentary behavior changes. In this revised questionnaire, individuals were asked to recall the frequency that each process was used in the previous month and to rate the frequency of occurrence on a 5-point Likert-type scale that ranged from 1 (never) to 5 (repeatedly). The Cronbach's alpha coefficient was calculated as a measure of internal consistency for the scale, which resulted in alpha levels that ranged from 0.65 to 0.86. In addition, 2-week test-retest reliability measures were performed as a measure of instrument stability, with reliabilities that ranged from 0.62 to 0.87.

Decision balance measure: This construct focuses on the importance of the perceived positive (pros) and negative (cons) outcomes of a behavior change [36]. It is assumed that an

Table 3. Means and standard deviations of the process of stage, decision balance, and self-efficacy across the five stages of sedentary behavior in Chinese high school students

Variable	Pr (n = 967)	C (n = 735)	P (n = 655)	A (n = 316)	M (n = 749)	P, h^2	Tukey's HSD[a]
Process of stage	35.32 ± 11.01	41.48 ± 9.64	42.04 ± 10.43	40.34 ± 10.97	38.89 ± 11.00	< 0.001, 0.058	Pr < C < P, Pr < M, A < P
Decision balance (cons)	19.48 ± 4.05	18.69 ± 3.40	18.42 ± 3.80	18.29 ± 3.88	19.03 ± 3.73	< 0.001, 0.013	C, P, A < Pr, P, A < M
Decision balance (pros)	18.90 ± 3.78	19.59 ± 3.23	19.64 ± 3.66	19.41 ± 3.57	19.27 ± 3.52	< 0.001, 0.007	Pr < C, P, M
Self-efficacy	20.40 ± 5.55	21.45 ± 4.96	22.05 ± 4.92	21.16 ± 4.63	21.40 ± 5.44	< 0.001, 0.012	Pr < C, P, M

Note: Pr = Pre-contemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance. [a]Mean differences for the Tukey's HSD pairwise comparisons (P < 0.05).

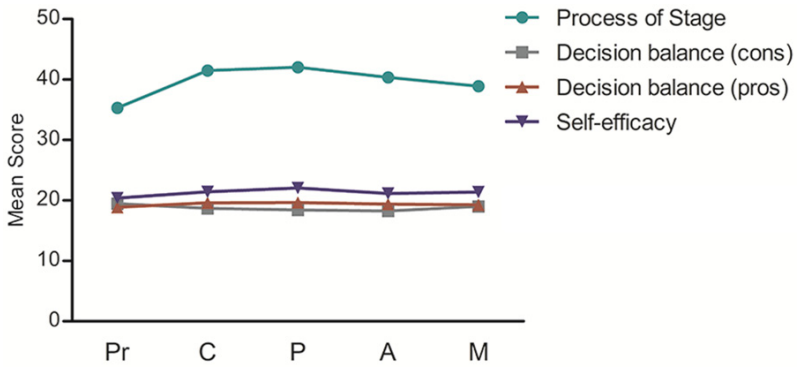

Figure 1. Changes in the transtheoretical model constructs according to the stage of sedentary behavioral change in Chinese high school students. Note: Pr = Pre-contemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance.

individual will not change her or his behavior unless he or she perceives that the positives of change outweigh the negatives. A 10-item questionnaire was developed to assess the "positive (pros) effect" and "negative (cons) effect" of reducing sedentary time. The participants were asked about the importance of their decision to watch TV or play a game on the computer using a 5-point Likert-type scale that ranged from 1 (not at all important) to 5 (extremely important). Examples of the "pro" items included "I think television watching is boring" and "I think playing video games is boring". Examples of the "con" items included "I think dealing with business while seated is relaxing" and "I think watching television is relaxing". The internal consistency was α = 0.65 for the pros and α = 0.81 for the cons. In addition, the 2-week test-retest reliabilities for the pro and con scales were 0.88 and 0.76, respectively.

Self-efficacy measure: Self-efficacy is defined as an individual's perceived confidence in the ability to successfully respond to emergencies, rather than yielding to unhealthy or risky behaviors [41]. The reducing sedentary self-efficacy scale consisted of 7 items with a 5-point Likert-type scale that ranged from 1 (cannot do) to 5 (definitely can do). The scale was developed to evaluate adolescents' confidence in their ability to reduce sedentary time. An example item included "deciding which television program to watch on weekends ahead of time". The ranges of scores regarding the change strategy, positive and negative effects of the decision balance, and self-efficacy were 15-75, 6-30, 6-30, and 7-35, respectively. The Cronbach's alpha coefficient was calculated as a measure of the scale's internal consistency, and a standardized value of 0.87 was obtained. In addition, the 2-week test-retest reliability was examined as a measure of instrument stability, which resulted in a reliability coefficient of 0.84.

Data analysis

All statistical analyses conducted in this study were performed using SPSS version 17.0. Descriptive analyses (i.e., the mean, maximum, minimum, and SD) and Chi-Square tests were initially conducted to examine the sedentary behavior distribution of high school students in China. The sedentary time was compared via sex and grade using t-tests. A series of one-way analyses of variance (ANOVAs) and *F* tests were performed using the sedentary behavior stage as the independent variable and the sedentary time, processes of change, self-efficacy, and decision balance as the dependent variables. Tukey's honestly significant different (HSD) was used to identify significant changes when necessary. Eta-squared values were used to report

Table 4. Binary logistic regression model for sedentary behavior in Chinese high school students

Independent variables	Dependent variable: Sedentary behavior on weekdays sedentary time > 6 hours = 1, ≤ 5 hours = 0			Dependent variable: Sedentary behavior on weekends sedentary time > 5 hours = 1, ≤ 4 hours = 0		
	Odds ratio	95% Confidence interval	P	Odds ratio	95% Confidence interval	P
Sex (ref = boys)	1.33	1.15-1.53	< 0.001	1.17	1.01-1.35	0.035
Grade (ref = junior high school)	1.74	1.51-2.01	< 0.001	1.61	1.38-1.87	< 0.001
Stage of change (ref = pre-contemplation)						
Contemplation	0.73	0.60-0.89	0.002	0.88	0.72-1.08	0.22
Preparation	0.55	0.53-0.87	< 0.001	0.53	0.42-0.65	< 0.001
Action	0.27	0.20-0.37	< 0.001	0.36	0.27-0.48	< 0.001
Maintenance	0.78	0.64-0.95	< 0.001	0.60	0.49-0.73	< 0.001
Processes of change	0.98	0.97-0.99	< 0.001	0.98	0.97-0.99	< 0.001
Cons on decision balance	1.05	1.03-1.07	< 0.001	1.10	1.07-1.12	< 0.001
Pros on decision balance	-	-	-	0.97	0.95-0.99	0.017
Self-efficacy	-	-	-	0.97	0.96-0.99	< 0.001

Note: Binary logistic regression model was used to analyze the effect of processes of change, self-efficacy, and decision balance on sedentary behavior after adjustment for sex and grade.

the variance explained in each test. The eta-squared values were interpreted as small (< 0.06), medium (0.06-0.14), and large (> 0.14) on the basis of guidelines outlined by Cohen [42]. Finally, a logistic regression analysis was used to examine the relationships between sex, grade, stage of change, TTM constructs, and sedentary behaviors. Significance was set at $P < 0.05$.

Results

Stage of change

The sedentary activity stage distributions via sex and grade are shown in **Table 1**. The difference between the stage distributions of the male and female students was significant ($X^2 = 17.45$, $P = 0.002$), and there was a significant difference ($X^2 = 81.11$, $P < 0.001$) between the stage distribution of the junior and senior high school students. However, there was no difference in the stage distributions in the three geographical areas in China.

Sedentary time

On weekdays and weekends, the students' sedentary times in the three cities were not significantly different (**Table 2**; $P > 0.05$), whereas the female students exhibited more sedentary time compared with the male students ($P < 0.001$). Furthermore, the senior high school students exhibited more sedentary time compared with the junior high school students ($P < 0.05$). The sedentary behavior stage accounted for significant variance in the sedentary time on weekdays ($F_{(4,3418)} = 39.72$, $P < 0.001$, $\eta^2 = 0.044$) and weekends ($F_{(4,3418)} = 40.31$, $P < 0.001$, $\eta^2 = 0.045$) in the entire sample. For male and female students, as well as the junior and senior high school students, Tukey's post hoc tests identified significant decreases in the sedentary time from the pre-contemplation to action stages.

When the sedentary times spent on weekdays and weekends were compared, the findings indicated that the sedentary time spent on weekdays was greater than that on weekends ($t = 3.72$, $P < 0.001$). For the female students, the sedentary time on weekdays was greater than that on weekends ($t = 4.13$, $P < 0.001$), whereas there was no significant difference between the sedentary times on weekdays and weekends for the male students ($t = 1.35$, $P = 0.18$). For the junior high school students, the sedentary time on weekdays was significantly longer than on weekends ($t = 4.88$, $P < 0.001$), whereas there was no significant different between the sedentary times on weekdays and weekends in the senior high school students ($t = 0.24$, $P = 0.81$).

TTM constructs

The mean scores of the students' change strategy, pros of decision balance, cons of decision

balance, and self-efficacy in different stages are shown in **Table 3**. **Figure 1** demonstrates the change trends of the TTM constructs across the stages of behavioral change.

The TTM constructs were significantly associated with the stage of change for sedentary behavior. The behavioral processes of change were significantly different across the stages of change for sedentary behavior ($F_{(4,3418)}$ = 52.87, P < 0.001, η^2 = 0.058). Post hoc tests indicated that the high school students in the pre-contemplation stage had significantly lower scores for the processes of change compared with the students in the contemplation, preparation, action, and maintenance stages. Regarding the cons on the decision balance, there was a significant difference between the stages of change ($F_{(4,3418)}$ = 11.12, P < 0.001, η^2 = 0.013). Tukey's post hoc tests indicated the scores regarding the cons on decision balance decreased from the pre-contemplation to action stages. The stages of change accounted for the significant variance in the pros on decision balance ($F_{(4,3418)}$ = 5.75, P < 0.001, η^2 = 0.007) and self-efficacy ($F_{(4,3418)}$ = 7.75, P < 0.001, η^2 = 0.012). Post hoc tests identified significant increases in the pros on decision balance and self-efficacy from the pre-contemplation to maintenance stages.

Logistic regression model for sedentary behavior

Table 4 shows the results of the binary logistic regression analysis. On weekdays, the female students were more likely to spend more than 6 hours engaged in sedentary behavior compared with the male students (odds ratio [OR]: 1.33, 95% confidence interval [CI]: 1.15-1.53), and the senior high school students were significantly more likely to spend more time engaged in sedentary behavior compared with the junior high school students (OR: 1.74, 95% CI: 1.51-2.01). The high school students in the preparation, action, and maintenance stages reported less sedentary hours compared with the students in the pre-contemplation stage. Increased scores regarding the processes of change (OR: 0.98, 95% CI: 0.97-0.99) were related to a decreased likelihood of being in the high-sedentary-behavior group. High scores regarding the cons of decision balance (OR: 1.05, 95% CI: 1.03-1.07) were related to an increased likelihood of being in the high sedentary time group.

On weekends, the female students were more likely to be in the > 6 hours of sedentary time group on weekdays compared with the male students (OR: 1.17, 95% CI: 1.01-1.35), and the senior high school students were significantly more likely to spend more time engaged in sedentary behavior compared with the junior high school students (OR: 1.1.61, 95% CI: 1.38-1.87). The high school students in the preparation, action, and maintenance stages (OR: 0.53, 95% CI: 0.42-0.65; OR: 0.36, 95% CI: 0.27-0.48; and OR: 0.60, 95% CI: 0.49-0.73, respectively) reported less sedentary time compared with the students in the pre-contemplation stage. Increased scores regarding the processes of change, pros on decision balance, and self-efficacy were related to a decreased likelihood of being in the high-sedentary-behavior group. High scores regarding the cons of decision balance were related to an increased likelihood of being in the high-sedentary-time group.

Discussion

Few studies have investigated sedentary behavior in China. In this study, we demonstrated that the average sedentary time of high school students in China was more than 4 hours per day. Moreover, the sedentary time on weekdays was longer than that on weekends, which is most likely related to the substantial learning pressure imposed on high school students in China. During school days, students are required to complete homework, which makes it difficult to reduce their sedentary time. Therefore, studies regarding the sedentary behavior of high school students must consider the current situation of the education system. However, our study undoubtedly indicates that high school students in China lead a sedentary lifestyle, which is not ideal for their growth; thus, this research topic should receive substantial attention from school educators, health workers, and parents. Active measures should be taken to reduce the sedentary time of high school students.

The prevalence of sedentary behavior identified in the Chinese high school students in the present study was remarkably high. The prevalence of sedentary behavior was 47.3% on weekdays and 45.2% on weekends, and these values are higher than those previously reported for Chinese school children [43]. On average, the participants spent 4.25 hours/day on

weekdays engaged in sedentary behavior, which is higher than previously reported for Scottish adolescents and similar to the results of Van et al [44, 45]. Consistent with previous studies [46], the sedentary time was significantly greater in the senior high school students compared with the junior high school students, which is most likely related to the increased pressure to study for the college entrance examination that results in long study hours after school. The male students reported less sedentary time compared with the female students, which may be related to a natural tendency for males to be more active in some circumstances and is similar to the findings of Bandura et al [37, 41]. For example, in China, males are more likely to play football or group sports outside, whereas females are more likely to engage in activities at home [43]. In addition, females and males engage in sedentary behaviors in different ways, which may be the result, in part, of sex-dependent differences in natural instincts. Females are more likely to spend considerable time in communication-based sedentary behaviors, such as talking on the phone, texting, and instant messaging, whereas males are more likely to watch television and videos or play computer games [47].

The analysis of the relationships between the sedentary time and stages of change indicated that the students' sedentary time was different across the stages of change. Specifically, the students' sedentary time tended to decrease from the pre-contemplation to action stages, which is consistent with Norman's report [36]. This information could facilitate the design of stage-matched, sedentary time reducing interventions for specific populations in the future. Furthermore, the scores regarding the processes of change, decision balance (pros and cons), and self-efficacy were significantly different across the stages of change, which suggests the students' sedentary behavior was affected by the TTM constructs [48, 49].

The findings indicated that the scores of the students' processes of change, pros of decision balance, and cons of decision balance were highest in the contemplation stage, which suggests these students do not possess sufficient knowledge regarding the benefits and impediments of reducing sedentary time. For students in this stage, cognitive education should be emphasized during health education, which would enable them to realize the harm of sedentary behavior and provide them with enjoyable activities to reduce sedentary behavior. The change process score was higher in the students in the contemplation stage compared with the action stage, which indicates students in the contemplation stage spend more time overcoming the obstacle. For these students, it is important to offer them options and approaches to reduce sedentary behavior. In the preparation stage, the four-dimension scores are high, which suggests these four dimensions have the strongest relationships with the preparation stage. The students in this stage have realized the negative consequences of sedentary behavior on their health and have the confidence to overcome the impediment. Special attention should focus on creating a beneficial environment that is conducive to reduce sedentary behavior and strengthen their confidence. In the maintenance stage, the students had developed good habits to reduce sedentary time; thus, the four-dimension scores were not high. Additional attention should focus on health education regarding the consolidation and enforcement of good habits in these students.

The results of the univariate analysis of sedentary behavior indicate that the change strategy, decision balance (pros), and self-efficacy were positively correlated with the stages of change, whereas the decision balance (cons) had a negative relationship with the stages of change. These results are consistent with findings from previous studies in other countries and are in accordance with the TTM [13, 22].

The logistic regression analysis of sedentary behaviors indicated the increased scores regarding the processes of change, pros on decision balance, and self-efficacy were related to a decreased likelihood of being in the high-sedentary-behavior group, and the increased scores regarding the cons of decision balance were related to an increased likelihood of being in the high-sedentary-time group [36], which is consistence with Norman's report. These findings indicate that high school students have the awareness to reduce sedentary time and attempt to overcome obstacles, such as reducing the time engaged in computer or television use. However, because of the current educational system in China, a substantial learning pressure drives high school students to spend

more time on homework and reading. Despite an awareness of the benefits of reducing sedentary time and the confidence to implement changes, students have no time to achieve these goals. Thus, it is necessary to explore alternative effective approaches that ensure students can complete their schoolwork efficiently in fewer hours with less sedentary time.

Several limitations in the current research warrant consideration. First, students in grades 9 and 12 were not recruited as participants because of the substantial learning pressures that result from the entrance examinations. Thus, the current sample does not represent all high school students. Second, self-reported sedentary time may be underestimated because of recall bias; however, the differences between self-reported and objective measures have been demonstrated to be minor [39]. Another potential limitation is that the behavioral and psychological questionnaires used in the study rely on self-report bias, which results in an unspecified number of misclassifications regarding the participant's actual sedentary behavior levels; moreover, these errors are difficult to assess because of the use of a questionnaire rather than an interview format. Furthermore, the current research comprised a cross-sectional survey; therefore, the developmental trends in the stages of change regarding sedentary behavior could not be identified. A longitudinal study that includes interviews in addition to questionnaires is recommended in the future to examine the stability of different sedentary behavior predictors. Finally, the current study focused on the relationships between sedentary behavior and stages of change. However, we acknowledge that other factors, such as parental education, family socioeconomic status, social support, and cultural background, may also influence the prevalence of sedentary behavior; these variables should be taken into account in future research.

In conclusion, high school students in China engage in a substantial amount of sedentary behavior. Most students are in the pre-contemplation stage; thus, the need to change the current situation regarding student sedentary behavior is urgent. The solutions include a requirement that education authorities reform the education system, as well as an increase in the awareness to reducing sedentary behavior and decreasing the overloaded study pressure. These findings provide psychometric evidence for the psychosocial measures related to adolescent sedentary behaviors, as well as critical information regarding the need to modify after-school activities. The measures can be useful in the development and assessment of tailored interventions designed to reduce sedentary time in high school students in China.

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Disclosure of conflict of interest

None.

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