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Associations of cardiorespiratory fitness, screen time and mental health among Chinese school children

Rui Li, MD[a], Min-Zhe Zhang, PhD[b], Bo-Wen Tang, PhD[b], Jie Zhang, MPH[b], Geng-Cong Qu, MPH[b], Hui Li, MPH[b,c], Yuan-Mei Shi, MD[d,*]

Abstract

To assess the independent and joint associations between cardiorespiratory fitness (CRF), screen time and mental health among Chinese school-aged children, a cross-sectional study was conducted in 3 primary schools in Wuhan city, China. Children self-reported ST, and their height, weight and CRF were measured. Mental health (anxiety, depressive symptom, and self-esteem) was assessed by self-administered questionnaires. A total of 805 children aged 9.1 ± 0.6 years participated in this study. High ST was associated with significantly increased risk for anxiety and low self-esteem, while high CRF was associated with a decreased risk of low self-esteem. In the joint model, children with low ST and high CRF showed the lowest risk for anxiety (OR: 0.42, 95%CI: 0.20–0.89) and low self-esteem (OR:0.44, 95%CI: 0.24–0.82). High ST and low CRF were negatively associated with mental health in Chinese schoolchildren. Health care and interventions on limiting ST and improving CRF level are warranted to promote the mental health in this population.

Abbreviations: BMI = body mass index, CI = confidence interval, CRF = cardiorespiratory fitness, DSRSC = depression self-rating scale for children, FV = fruit and vegetable intake, OR = odd ratios, PA = physical activity, ST = screen time, VO_2max = predicted maximum oxygen uptake.

Keywords: cardiorespiratory fitness, children, mental health, screen time

1. Introduction

It has been reported that 13.4% of children and adolescents suffered from mental disorders worldwide in 2015,[1] and poor childhood mental health may cause many negative consequences, including low academic performance, interpersonal difficulty, substance abuse, and suicide.[2,3] Besides, adolescents with psychological problems are more likely to develop the conditions in adulthood.[4] Therefore, it is important to identify early risk factors and find effective intervention measures to improve childhood mental health.[5]

Previous research indicates that several potential modifiable behavior factors, such as screen time (ST) and physical fitness, are associated with children's mental well-being. As the most common secondary behavior, ST has been shown to be related to an increased risk for poor mental health,[6,7] but there is no consensus in children.[8] Some reported negative but small effects, while others suggested beneficial impact.[9,10] Meanwhile, cardiorespiratory fitness (CRF), which refers to the ability of the circulatory and respiratory system to supply oxygen to skeletal muscles during sustained exercise, has been linked to mental health in adults, but findings in children are limited. Furthermore, although ST has been found to impair the positive association of high CRF with academic attainment of schoolchildren, it is unclear whether there was an interaction effect between CRF and ST on their mental health.[11] Therefore, this study was conducted to explore the research question: whether there were independent and combined effects of ST and CRF on the risks of anxiety, depression, and self-esteem among children? We hypothesized that CRF and ST would be associated with psychological problems in Chinese school children.

2. Methods

A cross-sectional study was conducted in Wuhan, China between March and April, 2018. Three primary schools were recruited using a convenience sampling method. Students who met the following criteria: aged 8 to 10 years old; study in grade 3; 'free

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

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

The studies involving human participants were reviewed and approved by the Medical Research Ethics Committee of Wuhan University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

[a] *Medical Department, Taihe Hospital, Hubei University of Medicine, Shiyan, P.R. China,* [b] *School of Public Health, Wuhan University, P.R. China,* [c] *Medical Department, Taixing People's Hospital, Jiangsu, P.R. China,* [d] *Pediatrics Department, Taixing People's Hospital, Jiangsu, P.R. China.*

** Correspondence: Yuan-Mei Shi, Pediatrics department, Taixing People's Hospital, Changzheng Rd, No.1, Taixing, Jiangsu Province 225400, P.R. China (e-mail: 577808762@qq.com).*

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of known diabetes, heart disease, and disability, were invited to participate in the study. Children's anthropometric indices, health behaviors, and mental health were measured. Parents filled out a questionnaire at home to report their socioeconomic status. Written informed consent was obtained from parents of the children. The Medical Research Ethics Committee of Wuhan University approved this study.

2.1. Measures

Children's height and weight was measured by a group of research staff. Then they completed a self-administered questionnaire in classrooms that included information on their ST, mental health, and health behaviors.

ST Information on ST was asked by the question—During the last week, how many hours per day did you usually spend on television, computer/tablet, and cell phones? Response options included: None, <0.5 hour/day, 0.5 to <1 hour/day, 1 to <2 hours/day, 2 to <3 hours/day, and ≥ 3 hours/day. Children with high ST were defined as those who had ST ≥ 1 hour/day.[13,14]

CRF was determined by the 20-meter shuttle-run test, which is a useful measure of cardiorespiratory capacity and has been validated in children and adolescents.[14] Participants were asked to run back and forth on a 20-meter course at a pre-determined speed guided by audio signals from a CD player. The running speed was set to increase at 0.5 km/h each minute, from a start speed of 8.5 km/h. Groups of 6 children were instructed to run at speeds following the audio signal and to complete as many as laps as possible, until they could not cope. The children stopped when they could not follow the signal any more. Predicted maximum oxygen uptake (VO_2max) derived from the level (maximal speed) and number of laps in the test was used as a measure of CRF. Children in this study were classified into high or low CRF group based on the gender-specific median VO_2max values.

Mental health Depressive symptom was assessed by the Depression Self-rating Scale for Children (DSRSC).[15] The DSRSC is a self-report questionnaire that contains 18 items, with each item scored on a 3-point scale (0 = never, 1 = sometimes, 2 = often). The total scores ranged from 0 to 36. The reliability and validity of DSRSC have been examined in Chinese children. Higher scores on the DSRSC suggest a higher level of depressive symptom, with a total score of 15 was set as a cutoff point of depressive disorders.[16]

Social anxiety was determined by the Social Anxiety Scale for Children,[17] which was developed to evaluate children's feeling of social anxiety in the context of their peer relations. It included 10 items including 2 dimensions: negative evaluation and social avoidance and distress. The response to each item was scored on a 3-point scale (0 = always, 1 = sometimes, 2 = never). The total scores ranged from 0 to 20, with a total score above 7 indicating social anxiety.

Self-esteem was assessed using the Rosenberg self-esteem scale.[18] It contains 10 self-reported items that show one's general belief about herself/himself using a 4-point Likert scale. The overall scores ranged between 10 and 40. In the present study, children were categorized into high or low self-esteem group based on the median value.

Confounders Potential confounders included: children's body mass index (weight [kg]/height [m]^2)-z score, maternal education, children's physical activity (PA) (assessed by the question - How often do you sport and/or vigorous free play each week with 60 min at least per day?), fruit and vegetables intake (assessed by the question - During the past 30 days, how many times per day did you usually eat fruit/vegetables?).

2.2. Statistical analysis

Statistical analyses were conducted using the SPSS statistical package (version 13.0; SPSS Inc., Chicago, IL). The differences in the characteristics between boys and girls were examined using t test and Chi-square test, where appropriate. Multiple logistic regression models were used to determine the odd ratios (ORs) and 95% confidence intervals (CIs) of the independent and interactive relationships of ST and CRF with mental health among participants.

3. Results

Of a total of 872 children, 805 (92.3%) aged 9.1(SD:0.6) years with completed data were included in the final analysis (Fig. 1). As shown in Table 1, boys had significantly higher body mass index and a higher prevalence of high ST than girls, while the

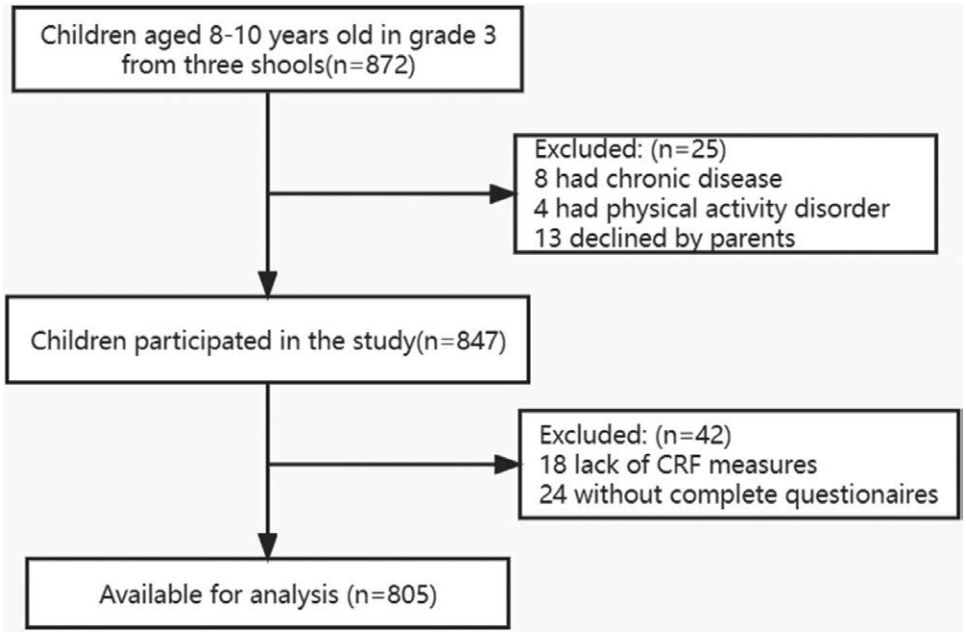

Figure 1. Participants flow diagram.

difference of maternal education, PA and fruit and vegetable intake were not significantly different between genders.

Table 2 displays the independent association between ST, CRP, and mental health. Compared to their counterparts, children with high ST showed significantly increased risks for anxiety (OR: 1.72, 95%CI: 1.06–2.80) and low self-esteem (OR: 1.63, 95%CI: 1.07–2.48), while high CRF was associated with significantly reduced risk for low self-esteem (OR: 0.61, 95%CI: 0.40–0.93).

The interactive relationships of ST and CRF with mental health are presented in Table 3. In general, children with high CRF and/or low ST showed a lower risk of mental disorders, and the lowest risk for anxiety (OR: 0.42, 95%CI: 0.20–0.89) and low self-esteem (OR:0.44, 95%CI: 0.24–0.82) were found among children with low ST and high CRF.

4. Discussion

In this study, we found that both low CRF and high ST were independently associated with an increased risk of psychological problems in Chinese school children. When analyzing jointly, children with high CRF and low ST showed the lowest risk of anxiety and low self-esteem.

Table 1

Basic characteristics of participants.

	Total	Boys (n = 445)	Girls (n = 360)	*P* value
Age	9.1 (0.6)	9.1 (0.6)	9.1 (0.6)	.073
Height	137.0 (5.8)	137.3 (5.9)	136.7 (5.7)	.147
Weight	32.3 (7.0)	33.2 (7.4)	31.3 (6.3)	<.001
BMI	17.1 (2.9)	17.5 (3.0)	16.6 (2.6)	<.001
Maternal education				.592
Low	3.7	4.0	3.5	
Middle	30.4	28.7	32.4	
High	65.9	67.4	64.1	
FV				.090
Low	78.8	76.6	81.6	
High	21.2	23.4	18.4	
PA				.512
Low	47.3	46.3	48.6	
High	52.7	53.7	51.4	
ST				.035
Low	80.6	78.0	83.9	
High	19.4	22.0	16.1	
VO_2max	42.8 (3.6)	43.72 (3.9)	41.8 (3.0)	<.001

Data are presented as mean (SD) or number (percentage).

BMI = body mass index, FV = fruit and vegetables intake, PA = physical activity, ST = screen time, VO_2max = predicted maximum oxygen uptake.

Table 2

Associations between ST, CRP, and mental health among participants.

	Anxiety		Depression		Low self-esteem	
	OR	95%CI	OR	95%CI	OR	95%CI
ST						
Low	1.00		1.00		1.00	
High	1.72*	1.06–2.80	0.97	0.57–1.64	1.63*	1.07–2.48
CRP						
Low	1.00		1.00		1.00	
High	0.65	0.39–1.09	0.87	0.52–1.45	0.61*	0.40–0.93

Adjusted for school, age, gender, BMI, maternal education, PA, and FV.

BMI = body mass index, CI = confidence interval, CRF = cardiorespiratory fitness, FV = fruit and vegetables intake, ST = screen time, PA = physical activity.

*$P < .05$.

In accordance with previous cross-sectional studies,[6,19] our study suggested that high ST was significantly associated with an increased risk of anxiety. Similarly, Gunnell et al found that higher ST was related to anxiety cross-sectionally and longitudinally in 1160 adolescents during an 11-year period, powerfully supporting our findings.[20] Furthermore, we observed an inverse association between high ST and self-esteem, whereas similar results have been reported by studies from Canada[21] and USA.[22] However, a J correlation between ST and self-esteem was reported among children in Hong Kong, with TV viewing of 1 to 2 hour/day being favorable and >4 hour/day being related to the highest risk of low self-esteem.[23] Furthermore, the association between ST and depressive symptom was not significant in our study, which is consistent with the study by Hume et al, who reported neither cross-sectional nor longitudinal associations between ST and symptoms of depression among adolescents.[24] In contrast, Cao et al found that Chinese youth with a high ST had a higher risk of depression.[19] Thus, further studies are needed to draw a conclusive relationship between ST and mental health problems among children.

Although 2 studies reported beneficial impacts of physical fitness on psychological outcomes in adults,[25,26] findings among children are limited. In the present study, we found that CRF was associated with a decreased risk of mental health problems in schoolchildren, although only the association between CRF and self-esteem was statistically significant. One cross-sectional study by Greenleaf et al also found a positive association between CRF and self-esteem in middle school students, but only significant in girls.[27] Another intervention study reported that Hispanic children who underwent 6-week aerobic exercise had a significant improvement in depression, anxiety, and self-esteem.[28] Taken together, these results suggest that it is crucial to assess and improve CRF for better mental health among children.

In the joint model, we found that low ST and high CRF were combined to influence the risk for anxiety and low self-esteem. Although 2 studies found that high ST and low PA were interactively associated with higher prevalence of psychological problems in Chinese adolescents,[19,29] to the best of our knowledge, no previous investigation has examined the joint effects of ST and CRF on childhood mental health. Our findings may be explained by the combination of mechanisms of ST and CRF. Evidence indicated that children who spent long time watching TV were more likely to isolate themselves,[30] which may lead to mental health impairment.[31] Moreover, ST can displace the time spending in PA,[7] while lack of PA had a negative impact on individual's mental health.[32] On the other hand, high CRF

Table 3

Joint associations between ST, CRF, and mental health among participants.

	Total number(Boys)	Anxiety		Depression		Low self-esteem	
		OR	95%CI	OR	95%CI	OR	95%CI
High ST low CRF	84 (52)	1.00		1.00		1.00	
High ST high CRF	72 (46)	0.86	0.35–2.15	0.70	0.25–1.96	0.89	0.40–2.02
Low ST low CRF	319 (171)	0.68	0.36–1.29	0.93	0.47–1.85	0.76	0.43–1.33
Low ST high CRF	330 (176)	0.42*	0.20–0.89	0.85	0.40–1.81	0.44†	0.24–0.82

Adjusted for school, age, gender, BMI z scores, maternal education, PA, and FV.

BMI = body mass index, CI = confidence interval, CRF = cardiorespiratory fitness, FV = fruit and vegetables intake, PA = physical activity, ST = screen time.

*$P < .05$.

†$P < .001$.

has been shown to be inversely associated with body weight gain in school children,[33] hence leading to enhanced body satisfaction and improved mental fitness. Furthermore, high CRF may affect neurochemicals in the brain, such as serotonin or endorphins that function to elevate psychological well-being.[34] Therefore, high fitness and low ST may synthetically play a positive role in children's mental health.

There were several limitations in this study. First, the nature of cross-sectional design limited our ability to explore the causal relationship between ST, CRF, and mental health. A follow-up study may be helpful to identify the causality. Second, ST was assessed by a self-administered questionnaire, which may introduce recall and reporting bias into our study. However, it has been found that brief self-reported questionnaire was adequate for ST comparison among groups.[35] Third, CRF was not measured directly. Nevertheless, previous studies have shown that this test was reliable and highly predicted the measured VO_2max values in laboratory.[14] Fourth, although participants' mental health was evaluated by standardized questionnaires, these measures are not equivalent to clinical diagnoses, thus future studies with diagnostic interviews are warranted. Last, the study participants were recruited from 3 primary schools in Wuhan, China. Therefore, the generalization our findings to other population should be made with caution.

In conclusion, we provided evidence that high ST and low CRF were significantly associated with mental health problems in Chinese schoolchildren. Our findings have significant implications for developing health care and interventions on limiting ST and improving CRF levels to promote children's mental health.

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Author contributions

Conceptualization: Rui Li, Hui Li.
Data curation: Hui Li, Yuan-mei Shi.
Formal analysis: Rui Li, Hui Li, Yuan-mei Shi.
Investigation: Min-zhe Zhang, Bo-wen Tang, Hui Li, Yuan-mei Shi.
Methodology: Rui Li, Jie Zhang, Geng-cong Qu, Hui Li, Yuan-mei Shi.
Project administration: Min-zhe Zhang, Bo-wen Tang.
Validation: Hui Li, Yuan-mei Shi.
Visualization: Hui Li, Yuan-mei Shi.
Writing – original draft: Rui Li, Hui Li, Yuan-mei Shi.
Writing – review & editing: Rui Li, Min-zhe Zhang, Bo-wen Tang, Jie Zhang, Geng-cong Qu, Hui Li, Yuan-mei Shi.

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