

Original article

Prevalence and correlates of meeting the muscle-strengthening exercise recommendations among Chinese children and adolescents: Results from 2019 Physical Activity and Fitness in China—The Youth Study

Fei Xin^{a,†}, Zheng Zhu^{b,c,†}, Sitong Chen^d, Huan Chen^a, Xiaoqing Hu^a, Xiao Ma^e, Kun Liang^a, Yang Liu^{a,b}, Lijuan Wang^a, Yujun Cai^a, Ang Chen^f, Yan Tang^{a,*}

^a School of Physical Education and Sport Training, Shanghai University of Sport, Shanghai 200438, China

^b Shanghai Research Centre for Physical Fitness and Health of Children and Adolescents, Shanghai University of Sport, Shanghai 200438, China

^c School of Kinesiology, Shanghai University of Sport, Shanghai 200438, China

^d Institute for Health and Sport, Victoria University, Melbourne, VIC 3000, Australia

^e Institute of Sport Sciences, Shanghai University of Sport, Shanghai 200438, China

^f Department of Kinesiology, University of North Carolina at Greensboro, Greensboro, NC 27402, USA

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Abstract

Purpose: This study aimed to describe the national prevalence of Chinese children and adolescents who met the World Health Organization muscle-strengthening exercise (MSE) recommendations and identify correlates of meeting the MSE recommendations.

Methods: Cross-sectional data from the 2019 Physical Activity and Fitness in China—The Youth Study, a nationally representative sample of Chinese children and adolescents ($n = 80,413$; mean age = 13.7 years; 53.9% girls) and their parents, were analyzed. Children and adolescents who reported engaging ≥ 3 days (up to 7 days) of MSE per week were classified as meeting the MSE recommendations. MSE, demographics, lifestyle behaviors (sport participation, moderate-to-vigorous physical activity, screen time, and sleep duration), exercise intention, peer and parental support, and parental MSE participation were assessed through self-reports. Logistic regression models were used to determine the correlates of meeting the MSE recommendations. The analyses were completed in 2020.

Results: Overall, 39.3% of children and adolescents met the MSE recommendations. Girls, 10th–12th graders, minorities, those from lower income households and those from families with lower parental education were less likely to meet the MSE recommendations. Children and adolescents who were proficient in ≥ 2 sports were more likely to meet the MSE recommendations (adjusted odds ratio (aOR) = 1.44, 95% confidence interval (95%CI): 1.26–1.65), as were those with more moderate-to-vigorous physical activity (aOR = 1.57, 95%CI: 1.53–1.61). Additionally, children and adolescents with high exercise intention (aOR = 1.60, 95%CI: 1.51–1.69), those whose parents met the adult MSE recommendations (aOR = 1.46, 95%CI: 1.40–1.52), and those who received high peer (aOR = 1.27, 95%CI: 1.20–1.34) and parental support (aOR = 1.07, 95%CI: 1.04–1.12) were more likely to meet the MSE recommendations.

Conclusion: Less than two-fifths of Chinese children and adolescents met the World Health Organization MSE recommendations. The correlates identified in our study can help inform the development of school and community based strategies and policies to enhance participation in MSE and improve muscular fitness of all Chinese children and adolescents.

Keywords: Exercise; China Youth Study; Health; Population-based; School-aged children; Strength training

1. Introduction

For children and adolescents, engaging in regular muscle-strengthening exercise (MSE) can have beneficial effects on the cardiorespiratory and musculoskeletal systems,^{1–3} cognitive outcomes,³ sports-injury risk,¹ and adiposity.^{1–3} The World Health Organization recommends

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* Corresponding author.

E-mail address: tybsh2011@126.com (Y. Tang).

† These two authors contributed equally to this work.

that young people (5–17 years old) should participate in activities to strengthen muscle and bone ≥ 3 days a week.³

MSE is defined as physical activity and exercise that increase skeletal muscle strength, power, endurance, and mass (e.g., strength training, resistance training, or muscular strength and endurance exercises).³ A nationally representative survey from the United States showed that 49.5% of high school students (39.7% of girls and 59.0% of boys) performed MSE ≥ 3 days per week.⁴ A similar MSE prevalence was observed among high school students in Canada (49.5% of girls and 57.9% of boys) in the COMPASS study.⁵ Additionally, a higher percentage of American students (84.4%) in Grades 6–8 met the MSE recommendations.⁶ By contrast, only 22.4% of Australian boys and 8.4% of girls aged 15–17 years met the MSE recommendations.⁷ Although the prevalence of MSE varied by sex and age, the overall level of MSE is high, with the exception of Australia. Population-based MSE surveys of children and adolescents are commonly conducted in the United States,^{4,6} Canada,⁵ and Australia,⁷ but there is no up-to-date population-based MSE surveillance of children and adolescents in China.

Understanding the factors influencing MSE participation is critical to designing effective MSE interventions. In this regard, socioecological models provide a suitable framework for studying the associations between MSE participation and demographic, psychological, behavioral, sociocultural, and environmental factors.⁸ To date, only Smith et al.⁹ have used a socioecological framework to examine factors associated with adolescents' MSE participation. Reviews of the literature show that previous studies have examined the associations between MSE participation and demographic factors, including sex,^{4–6,10} race,^{5,6,9,10} income,⁶ and body mass index;^{6,10} behavioral factors, including moderate-to-vigorous physical activity (MVPA),¹⁰ sleep duration,⁹ and cardiorespiratory and muscular fitness;^{6,9} psychological factors, including the perceived amount of daily physical activity¹⁰ and resistance training self-efficacy;⁹ and sociocultural factors, including peer and parental support.¹⁰ However, almost all of the previous studies were conducted in the United States,^{4,6,10} Canada,⁵ and Australia.⁹ Considering different cultural and social contexts, we cannot assume that the correlates of MSE or the strength of associations will be similar to those drawn from developed countries. In addition, there may be other influential factors that are associated with MSE that have not been explored previously. For example, evidence has suggested that exercise intention,¹¹ proficient sports,¹² and parental exercise participation¹³ were significant correlates of physical activity among Chinese children and adolescents. Whether or not these factors associate with MSE remains an open question.

Considering the serious decline in physical activity and fitness among Chinese children and adolescents,¹⁴ understanding the prevalence and correlates of meeting the MSE recommendations will be beneficial for developing school- and community-based health promotion policies and interventions. Therefore, the purposes of this study were to (1) determine the prevalence of meeting the MSE recommendations among Chinese children and adolescents and (2) examine the associations between meeting the MSE recommendations and demographic, behavioral, psychological, and sociocultural factors.

2. Methods

2.1. Study design and participants

The data analyzed in this study were from the 2019 Physical Activity and Fitness in China—The Youth Study (PAFCTYS). Briefly, the 2019 PAFCTYS was a nationally representative survey that aimed to assess the physical fitness and health level of Chinese children and adolescents. With administrative support from the Ministry of Education, this large cross-sectional survey was conducted in 31 administrative regions (22 provinces, 4 direct-controlled municipalities, and 5 autonomous regions) and Xinjiang Production and Construction Corps in China from October 2019 to December 2019. To achieve a balanced representation of economic development and rural–urban diversity, a selection of administrative cities and districts/towns was made with stratification by socioeconomic status within each urban and rural stratum. Accordingly, a multistage stratified and random cluster sample method was used in the 2019 PAFCTYS. The sampling procedure was implemented as follows: (1) 116 cities: 4 administrative cities were randomly selected from each of the 28 province-level units (112 administrative cities), and 4 direct-controlled municipality units (Beijing, Shanghai, Tianjin, and Chongqing) were also included; (2) 256 districts: 1 district in an urban area and 1 town in a rural area were randomly selected from each of the 112 administrative cities (224 districts or towns); similarly, 4 districts in an urban area and 4 districts in a rural area were selected from each of the 4 direct-controlled municipality units (32 districts); (3) 2 primary schools, 1 junior middle school, and 1 junior high school were randomly recruited from all schools in each district or town; and (4) among these schools, 1–2 classes from each grade (Grades 4–12) were recruited. At least 60 students (30 boys and 30 girls) from each grade were recruited. Details of the study design can be found elsewhere.¹⁵

Children who were in primary school Grades 1–3 were not included in this study due to their limited cognitive ability. The procedure used for cleaning invalid and missing data is shown in Fig. 1. A total of 121,128 students (Grades 4–12; 9–17 years old) and 110,305 parents answered the 2019 PAFCTYS survey. All students were recruited from 491 primary schools (9–12 years old), 249 junior middle schools (12–15 years old), and 245 junior high schools (15–17 years old). A total of 104,823 student questionnaires were able to be matched with parent questionnaires. After excluding 24,410 invalid or missing values, the final analyzed sample size was 80,413.

This study was approved by the Institutional Review Board of the Shanghai University of Sport and the principals of the selected schools in 2019. All of the children, adolescents, and parents were informed that participation was voluntary. Verbal informed consent was obtained from all participants before data collection. It should be noted that the term “parent” in this survey refers to any guardian who has the legal right and responsibility of taking care of a child (not limited to biological parents).

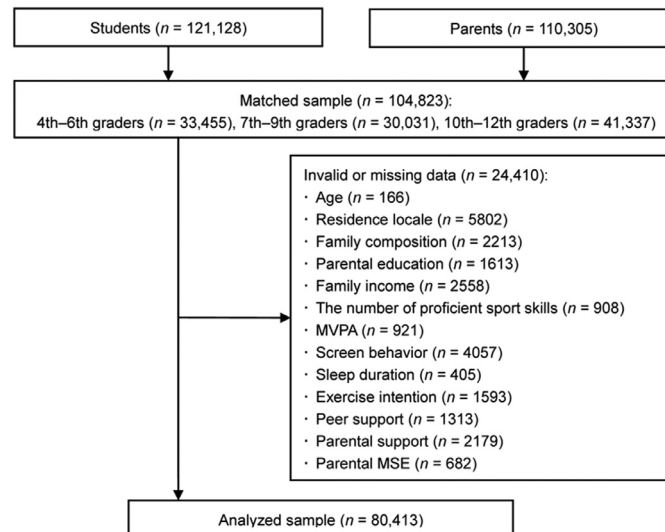


Fig. 1. The procedure used for cleaning invalid and missing data in this study. MSE = muscle-strengthening exercise; MVPA = moderate-to-vigorous physical activity.

2.2. Procedures

All of the selected students and their parents were informed about the research project before participation. Students' basic information, including sex, age, grade, and student number, was inputted into a subject file with a numeric identification code and subsequently entered into a computer database for authorized project staff. The process of data collection took place at school between October 2019 and December 2019. This period was selected so that physical fitness and health examinations could be conducted with administrative support from the Ministry of Education in China. First, each student independently completed a 4-page questionnaire¹⁶ either online (68%) or on paper (32%) in a classroom setting after receiving detailed instructions from trained research staff. In addition, the parents of each child were also asked to complete a 4-page self-report questionnaire (54% completed the online version and 46% completed the paper version) at home. Previous studies from PAFCTYS showed no differences in the results between the 2 response modes (online vs. paper).^{16–18} Trained research staff administered the survey and answered any questions about it. It should be noted that each student's questionnaire was matched with his (her) parent questionnaire by unique student numbers. A total of 16,305 student questionnaires or 5482 parent questionnaires were unmatched and excluded in the 2019 PAFCTYS.

2.3. Measures

2.3.1. Demographic variables

Demographic information, including sex, grade (4th–12th), ethnicity (Han or minority), and residential location (urban or rural), was obtained from the self-report questionnaires completed by the children and adolescents. The date of birth of each child was derived from the child's student number (date of birth is one of the components of the student number).

The number of siblings, caregivers, parental education level, and family income were obtained from the parent questionnaire. Socioeconomic status information, including education level (primary school or under, junior middle school, junior high school, college, university bachelor, and university master or higher) and family per-capita annual income (Chinese currency (RMB): <9000, 9000–30,000, >30,000–100,000, or >100,000), was collected based on the method developed by Cirino et al.¹⁹

2.3.2. Behavioral variables

Policies on physical education in China require students to be proficient in 1–2 sport skills.¹² The number of proficient sports was measured by the following item: “How many sport skills are you proficient in?” The response options for the number of sport skills that the participants were proficient in included 0, 1, 2, or >2 sports. This item has been used in a study by Zhu et al.¹² and has shown acceptable test–retest reliability (intraclass correlation coefficient (ICC) = 0.59) based on unpublished data.

MVPA information was collected by the following question: “Over the past 7 days, on how many days were you physically active for at least 60 min per day?” This question had 8 answer choices ranging from 0–7 days per week. Before this question, MVPA was defined as any kind of physical activity that increases your heart rate and makes you get out of breath some of the time (including physical education time, physical exercising, sports training, and various regular daily activities, such as brisk walking, hiking, and excursion). This item has shown acceptable test–retest reliability (ICC = 0.77) and concurrent validity (using the accelerometer as the standard, Pearson $r = 0.40$) for children and adolescents.²⁰

Screen time was measured by 6 items adapted from the Health Behavior in School-aged Children survey questionnaire,²¹ these items have been used in previous studies.^{12,17} To

collect screen-time information about the 6 items, the following question was used: “How many hours a day do you usually do the following things in your free time?” The 6 things were: (1) Watch TV or videos or DVDs on school days; (2) Watch TV or videos or DVDs at weekends; (3) Use a computer for playing games or use console games on school days; (4) Use a computer for playing games or use console games at weekends; (5) Use a computer for chatting online, internet, emailing, homework *etc.* on school days; and (6) Use a computer for chatting online, internet, emailing, homework *etc.* at weekends. Each question had 5 answer choices: 1 = *none*, 2 = *approximately half an hour*, 3 = *approximately 1 hour*, 4 = *approximately 2 hours*, and 5 = *approximately 3 hours or more*.

Sleep duration was measured by 1 item from the Chinese version of the Pittsburgh Sleep Quality Index questionnaire, which has shown test–retest reliability (ICC = 0.68) and concurrent validity (using the 7-day daily sleep log as the standard, Pearson $r = 0.60$) for children and adolescents.²² Participants were required to report their usual nightly sleep duration (in hours) on a normal day. Meeting the sleep guideline requires 9–11 h of uninterrupted sleep per night for those aged 5–13 years and 8–10 h per night for those aged 14–17 years.²³

2.3.3. Psychological variables

Information on exercise intention was collected using the following question: “What is your attitude towards participating in exercise in future study and life?” The response options were as follows: 1 = “I guarantee to participate in exercise every day just as now (Maintenance)”; 2 = “I will consider increasing my exercise frequency, and strive to participate in exercise every day (Action)”; 3 = “I will try to participate in exercise if have time, but I cannot guarantee that I will exercise every day (Preparation)”; 4 = “I will try to break the habit of not exercising and be open to participate in it (Contemplation)”; and 5 = “I do not like exercise, and have no plans to exercise in the future (Precontemplation)”. According to the transtheoretical model,²⁴ participants who reported the stages from “Action” to “Maintenance” were considered as showing high exercise intention and others were considered as showing low exercise intention. The self-designed item of exercise intention has shown acceptable test–retest reliability (ICC = 0.52) based on unpublished data.

2.3.4. Sociocultural variables

The sociocultural variables included peer support, parental support, and parental MSE. Information on peer support for participants was collected using the following questions: (1) “How often do your friends do physical activity or sports?”; (2) “How often do your friends do physical activity or sports with you?”; and (3) “How often do your friends encourage you to do physical activity or sports?” Children were asked to rate their agreement on a 5-point Likert scale ranging from 1 (*never*) to 5 (*always*), with total scores ranging from 3 to 15. Participants were categorized into low and high peer support using the median (12 points) as the cut point. The 3-item scale

has shown acceptable reliability (ICC = 0.86; Cronbach’s $\alpha = 0.81$).²⁵

Information on parental support for participants was measured using 6 items obtained from the parental questionnaire, including (1) “Do you encourage your child to participate in physical activity/exercise?”; (2) “Do you accompany your child when he/she participates in physical activity/exercise sessions?”; (3) “Do you provide financial support when your child engages in physical activity/exercise?”; (4) “Do you take part in physical activity/exercise together with your child?”; (5) “Do you share your knowledge of the health benefits of physical activity/exercise with your child?”; and (6) “Do you serve as a role model for your child by engaging in physical activity/exercise?” The responses to these questions were based on a 5-point scale ranging from 1 (*never*) to 5 (*always*), with higher scores indicating greater support for MSE and total scores ranging from 6 to 30. Participants were categorized into low and high parental support using the median (26 points) as the cut point. The 6-item scale was used in a previous study by Liu et al.¹⁶ and has a Cronbach’s α (internal consistency) coefficient of 0.82. This scale has also shown acceptable test–retest reliability (ICC = 0.51) based on unpublished data.

The following item was used to collect MSE information from the parents: “In the past week, how many days did you engage in MSE, such as push-ups, sit-ups, or lifting weights?” This question had 8 answer choices, ranging from 0 to 7 days per week. This item has shown acceptable test–retest reliability (ICC = 0.55)²⁶ and convergent validity (using the ≥ 2 times/week threshold against all-cause mortality)²⁷ in the adult population. Consistent with the World Health Organization’s guidelines, adults who reported engaging in MSE for ≥ 2 days (up to 7 days) in the past week were classified as meeting the recommendations.³

2.3.5. MSE

The following item was used to collect MSE information from the students: “In the past week, how many days did you engage in exercise to strengthen or tone the muscle, such as push-ups, sit-ups, or lifting weights?” The possible responses were as follows: 0 = *none*, 1 = 1 day, 2 = 2 days, 3 = 3 days, 4 = 4 days, 5 = 5 days, 6 = 6 days, and 7 = 7 days. This item has been used for health behavior surveillance in the United States,⁴ Canada,⁵ and other countries.^{9,10} Moreover, this item was confirmed to have acceptable reliability for children and adolescents (κ coefficient > 0.55).⁶ Consistent with the World Health Organization’s guidelines, children and adolescents who reported engaging in MSE for ≥ 3 days (up to 7 days) in the past week were classified as meeting the recommendations.³

2.4. Statistical analysis

Statistical analyses of all variables were performed using the Complex Sample module of SPSS (Version 24.0; IBM Corp., Armonk, NY, USA). To improve population representativeness, the final analyzed sample of the 2019 PAFCTYS was weighted against age, sex, and regional distributions provided

Table 1
Demographic characteristics of total sample ($n = 80,413$).

	<i>n</i>	Weighted (%) ^a (95%CI)
Sex		
Boy	37,362	46.1 (45.6–46.6)
Girl	43,051	53.9 (53.4–54.4)
Age group		
4th–6th graders	23,777	38.5 (36.3–40.7)
7th–9th graders	23,063	34.1 (32.1–36.1)
10th–12th graders	33,573	27.5 (25.8–29.1)
Ethnicity		
Han	73,722	92.1 (88.5–94.6)
Minority	6691	7.9 (5.4–11.5)
Residence location		
Urban	43,389	55.5 (50.4–60.4)
Rural	37,024	44.5 (39.6–49.6)
Family composition		
Single child	28,321	35.2 (32.5–38.0)
Two or more children	52,092	64.8 (62.0–67.5)
Parental education		
Primary school or under	7623	8.8 (7.6–10.2)
Junior middle school	27,295	32.8 (30.7–34.9)
Junior high school	13,305	16.2 (15.4–17.0)
College	18,466	23.9 (22.5–25.3)
University bachelor	11,524	15.3 (13.6–17.1)
University master or higher	2200	3.1 (2.5–3.7)
Family per-capita annual income (RMB)		
<9000	26,872	32.3 (30.4–34.2)
9000–30,000	27,920	34.6 (33.6–35.7)
>30,000–100,000	19,349	24.9 (23.5–26.4)
>100,000	6272	8.2 (7.2–9.4)

Note: Percentages might not add up to 100% due to rounding.

^a Data are weighted against age, sex, and regional distributions provided by the Ministry of Education of the People's Republic of China.

Abbreviation: 95%CI = 95% confidence interval.

by the Ministry of Education in China.¹⁷ First, descriptive analyses were used to report the characteristics of the sample and the prevalence of meeting the MSE recommendations. Second, logistic regressions were used to determine the associations between the prevalence of meeting the MSE recommendations and demographic, behavioral, psychological, and sociocultural variables. Adjusted odds ratios (aORs) with 95% confidence intervals (95%CI) were calculated for each variable. The level of statistical significance was set at $p < 0.01$ for all statistical tests.

3. Results

The demographic characteristics of the study sample are shown in Table 1. Among the 80,413 participants, the proportion of boys and girls was 46.1% and 53.9%, respectively. The percentages of the samples of the 3 grade groups were 38.5% (4th–6th graders), 34.1% (7th–9th graders), and 27.5% (10th–12th graders) (Percentages might not add up to 100% due to rounding). Participants in this study were mainly of Han ethnicity (92.1%) and were relatively evenly distributed in terms of place of residence (55.5% lived in urban areas). More than half of the children's parents (58.5%) reported that they had completed at least a high school degree.

Approximately 8.2% of families reported an income of more than RMB 100,000 per person, and 64.8% of the families had 2 or more children. The prevalence of participants meeting the MSE recommendations is shown in Table 2; overall, 39.3% of Chinese children and adolescents met the MSE recommendations.

The associations between multiple variables and meeting the MSE recommendations among the overall sample are shown in Table 2. At the demographic level, boys (aOR = 1.46, 95%CI: 1.40–1.52), 4th–6th graders (aOR = 1.16, 95%CI: 1.06–1.28), 7th–9th graders (aOR = 1.53, 95%CI: 1.39–1.70), and people of Han ethnicity (aOR = 1.22, 95%CI: 1.09–1.37) were more likely to meet the MSE recommendations. Compared to the lowest education group, children and adolescents whose parents had a college or higher education level were more likely to report the recommended level of MSE (college: aOR = 1.18, 95%CI: 1.08–1.30; university bachelor: aOR = 1.15, 95%CI: 1.04–1.27; university master or higher: aOR = 1.25, 95%CI: 1.02–1.52). Moreover, higher family income was positively associated with increased odds of reporting MSE ≥ 3 times/week, ranging from 1.07 (95%CI: 1.02–1.12) for an income of RMB9000–30,000 to 1.21 (95%CI: 1.12–1.31) for an income of more than RMB100,000. Place of residence and family composition were not significantly correlated with MSE participation.

At the behavioral level, children and adolescents reporting proficiency in ≥ 2 sports were 1.44 times (aOR = 1.44, 95%CI: 1.26–1.65) more likely to meet the MSE recommendations than those reporting proficiency in 0 sport. The frequency of weekly MVPA (≥ 60 min per day) was positively associated with higher odds of meeting the MSE recommendations (aOR = 1.57, 95%CI: 1.53–1.61). However, screen time and sleep duration were not significantly associated with MSE participation. At the psychological level, children and adolescents reporting high exercise intention were approximately 1.6 times (aOR = 1.60, 95%CI: 1.51–1.69) more likely to meet the MSE recommendations than those reporting low exercise intention. At the sociocultural level, children and adolescents whose parents met the adults' MSE recommendations were approximately 1.5 times (aOR = 1.46, 95%CI: 1.40–1.52) more likely to meet the recommended level of MSE. Furthermore, when there was high support from peers and parents, children and adolescents had higher odds of meeting the MSE recommendations (aOR = 1.27, 95%CI: 1.20–1.34 and aOR = 1.07, 95%CI: 1.04–1.12, respectively).

4. Discussion

To our knowledge, this study is the first to examine the prevalence and correlates of meeting the MSE recommendations in a nationally representative sample of Chinese children and adolescents. Our results demonstrated that the prevalence of meeting the MSE recommendations was low among Chinese children and adolescents aged 9–17 years. Previous studies mainly focused on adolescents in developed countries,^{4–7} among whom the prevalence of meeting the MSE

Table 2
Prevalence and aOR of meeting the MSE recommendations.

Variable	n (%)	Weighted (%) ^a (95%CI)	aOR (95%CI)
Total	29,822	39.3 (37.8–40.8)	–
Sex			
Boy	16,433 (55.1)	45.3 (43.9–46.8)	1.46 (1.40–1.52) **
Girl	13,389 (44.9)	34.1 (32.4–35.9)	1 (Ref.)
Age group			
4th–6th graders	10,388 (34.8)	43.7 (41.3–46.1)	1.16 (1.06–1.28) **
7th–9th graders	10,001 (33.5)	43.4 (40.9–45.9)	1.53 (1.39–1.70) **
10th–12th graders	9433 (31.6)	28.1 (26.7–29.6)	1 (Ref.)
Ethnicity			
Han	27,853 (93.4)	40.1 (38.4–41.7)	1.22 (1.09–1.37) **
Minority	1969 (6.6)	30.5 (27.4–33.8)	1 (Ref.)
Residence location			
Urban	17,428 (58.4)	42.3 (40.5–44.2)	1.08 (0.98–1.19)
Rural	12,394 (41.6)	35.5 (33.4–37.7)	1 (Ref.)
Family composition			
Single child	11,320 (38.0)	42.0 (40.2–43.9)	0.98 (0.94–1.04)
Two or more children	18,502 (62.0)	37.8 (36.2–39.5)	1 (Ref.)
Parental education			
Primary school or under	2183 (7.3)	30.3 (28.0–32.7)	1 (Ref.)
Junior middle school	9208 (30.9)	35.9 (34.3–37.5)	1.06 (0.98–1.14)
Junior high school	4938 (16.6)	39.2 (37.5–41.0)	1.09 (0.99–1.18)
College	7525 (25.2)	42.8 (41.0–44.7)	1.18 (1.08–1.30) **
University bachelor	4937 (16.6)	44.5 (42.2–46.9)	1.15 (1.04–1.27) **
University master or higher	1031 (3.5)	48.4 (43.9–52.8)	1.25 (1.02–1.52) **
Family per-capita annual income (RMB)			
<9000	8670 (29.1)	34.2 (32.6–35.9)	1 (Ref.)
9000–30,000	10,259 (34.4)	38.9 (37.4–40.5)	1.07 (1.02–1.12) **
>30,000–100,000	8055 (27.0)	43.7 (41.9–45.6)	1.16 (1.08–1.24) **
>100,000	2838 (9.5)	47.3 (44.6–50.1)	1.21 (1.12–1.31) **
Behavioral variable			
Zero proficient sport	1089 (3.7)	22.0 (19.6–24.6)	1 (Ref.)
One proficient sport	5884 (19.7)	30.1 (28.4–31.7)	1.07 (0.94–1.21)
Two or more proficient sports	22,849 (76.6)	44.2 (42.7–45.8)	1.44 (1.26–1.65) **
MVPA	–	–	1.57 (1.53–1.61) **
Screen time	–	–	1.00 (1.00–1.00)
Not met the sleep guidelines	24,368 (81.7)	38.8 (37.3–40.4)	1 (Ref.)
Met the sleep guidelines	5454 (18.3)	41.5 (39.4–43.6)	1.05 (0.99–1.10)
Psychological variable			
Low exercise intention	9175 (30.8)	26.3 (25.0–27.6)	1 (Ref.)
High exercise intention	20,647 (69.2)	49.6 (47.9–51.3)	1.60 (1.51–1.69) **
Sociocultural variable			
Low peer support	8320 (27.9)	28.3 (26.8–29.8)	1 (Ref.)
High peer support	21,502 (72.1)	45.9 (44.3–47.5)	1.27 (1.20–1.34) **
Low parental support	12,375 (41.5)	33.0 (31.6–34.5)	1 (Ref.)
High parental support	17,447 (58.5)	44.9 (43.3–46.5)	1.07 (1.04–1.12) **
Parent not met the MSE recommendations	18,699 (62.7)	35.3 (33.7–36.9)	1 (Ref.)
Parent met the MSE recommendations	11,123 (37.3)	48.8 (47.2–50.3)	1.46 (1.40–1.52) **

Note: Percentages might not add up to 100% due to rounding.

^a Data are weighted against age, sex, and regional distributions provided by the Ministry of Education of the People's Republic of China.

** $p < 0.001$, significant difference compared with variable in the same section set as Ref.

Abbreviations: 95%CI = 95% confidence interval; aOR = adjusted odds ratio; MSE = muscle-strengthening exercise; MVPA = moderate-to-vigorous physical activity; Ref. = reference.

recommendations was higher than among their Chinese counterparts. In addition to adolescents, we also provide information on the prevalence of MSE participation among 4th–6th graders. Most of the demographic, behavioral, psychological, and sociocultural factors, except location of residence, family composition, screen time, and sleep duration, were significantly associated with meeting the MSE recommendations among the overall sample.

The demographic correlates identified in our study were generally in line with previous studies. Being female^{4–6,10} and having lower socioeconomic status⁶ were consistently and inversely associated with meeting the MSE recommendations. Evidence has suggested that girls perceive greater barriers (such as homework, lack of time, lack of skill, lack of equipment, not liking to sweat) to engaging in physical activity, MSE, and sports than other populations.¹⁰ In addition, MSE

requires higher levels of skill/knowledge and access to space/facilities,²⁸ and these requirements are formidable barriers for children from lower education and lower income families. These findings highlight an urgent unmet need in current MSE public health intervention for these populations. We also examined the association between age groups and MSE participation. Previous studies found that the prevalence of youth MVPA decreased gradually with age from secondary school to high school.²⁹ Similarly, our study shows that the prevalence of meeting the MSE recommendations among 10th–12th graders was much lower than that among 4th–6th graders and 7th–9th graders. In the context of Chinese socioculture and education, this significant decline may be related to a lack of exercise habits, less exercise time, heavy academic pressure, and less support from parents, teachers, and friends. Therefore, families, schools, and communities should unite to provide interventions specifically targeting this population subgroup.

Regarding behavioral factors, a higher frequency of MVPA participation and more sport skills were positive correlates of meeting the MSE recommendations. Previous studies generally reported that both self-reported and objectively measured MVPA were positively and significantly associated with guideline-concordant MSE,^{9,30} which is consistent with our findings. Indeed, owing to the lack of distinction between aerobic exercise and MSE in the MVPA measurement item, the amount of MVPA reported in our survey may encompass a proportion of MSE participation. For example, in some regions of China, owing to the serious decline of physical fitness among children and adolescents,¹⁴ teachers usually provide 10 min of physical fitness exercise for students at the end of physical education lessons.³¹ In addition, coaches normally use MSE as a critical component in organized sport participation, which effectively and simultaneously increases the amount of physical activity and the frequency of MSE participation. Although some cross-sectional studies used MVPA as an independent variable for MSE,⁹ more longitudinal or interventional studies are needed to determine the causal relationship between MVPA and MSE. Another important finding in our study is that participants who were proficient in more sports were more likely to meet the MSE recommendations. Similarly, a recent cross-sectional study of 48,118 youths aged 6–18 years in Shanghai demonstrated that children reporting proficiency in more sports were more likely to meet physical activity recommendations.¹² As mentioned above, the process of motor skill learning, both in physical education lessons and sports participation, requires a certain frequency of MSE participation. Our findings enrich the current knowledge on the significance of proficient sports in association with physical activity and MSE participation. Furthermore, to some extent our findings verify the significant effect of the policy that students should be proficient in 1–2 sports to maintain a healthy lifestyle.

Exercise intention is assumed to be the most proximal determinant of human health behavior,³² and our study found that exercise intention was moderately associated with meeting the MSE recommendations. Numerous reviews have highlighted the significance of exercise intention for physical

activity among children and adolescents.^{8,33} However, for MSE behavior, only Smith et al.⁹ identified a strong association between resistance training self-efficacy and recommended levels of MSE among adolescents. The mediating effect of self-efficacy between exercise intention and physical activity has been fully verified in published studies.^{34,35} Considering the limited knowledge with regard to professional MSE training, it is reasonable to assume that only individuals with high self-efficacy can translate higher than usual exercise intention into MSE engagement. This assumption also provides a perspective for the use of self-efficacy interventions as a potentially efficient strategy for prompting MSE engagement among school-aged children. Therefore, physical education teachers and coaches should impart their professional MSE knowledge and skills to students in order to improve the students' confidence in MSE participation.

Peer and parental support are significant sociocultural correlates of meeting the MSE recommendations. A study by Roth et al.¹⁰ demonstrated the important roles that friends and parents played in adolescents' MSE participation. Interestingly, a previous study demonstrated that peer influences were more important than parental support in total physical activity,³⁶ and our study supports this view regarding MSE participation. Our finding emphasizes the importance of time spent with peers in relation to MSE level. Additionally, our study is the first to verify the associations between parents' and children's MSE participation. When parents achieved the recommended level of MSE, their children were more likely to report MSE 3 or more times per week. Theoretically, children engage in certain types of activities because they are exposed to their parents' patterns of activity through role modeling, observational learning, and parental transmission of attitudes and values.³⁷ Compared with encouragement, knowledge-sharing, and other parental support, regular parental involvement in MSE is more important in helping children to meet the recommended levels of MSE. Therefore, it may be appropriate for MSE interventions to involve parents and their children; to facilitate this, it is worth considering increasing the availability of MSE equipment at home (such as barbells and resistance bands) and opening fitness centers and providing fitness apparatus in the community.

4.1. Strengths and limitations

The strengths of the 2019 PAFCTYS include the use of large, nationally representative samples of Chinese children and adolescents, from which the findings, to a certain extent, could be widely generalized to different districts of China. Furthermore, the 2019 PAFCTYS is one of the few studies to identify the MSE prevalence among young people, and the first to determine the correlates of meeting the MSE recommendations among Chinese children and adolescents. However, some limitations of the 2019 PAFCTYS should be mentioned. First, given the cross-sectional study design, we could not determine a causal relationship. Second, most of the variables were measured by self-report questionnaire, which may lead to inaccuracies in prevalence. For example, children and

adolescents may define their own skill proficiency differently than an adult would. Third, several variables, including exercise intention, peer support, and parental support, were measured for general physical activity rather than specific MSE, which may disturb the associations between these variables and the recommended level of MSE. Fourth, body mass index is known to be associated with low levels of physical activity and muscular fitness in children and adolescents.⁹ However, the lack of height and weight measurements in our study precludes us from examining the important role of body mass index as a correlate of MSE in the Chinese child and adolescent populations. Therefore, the extent to which body mass index category is associated with MSE participation warrants investigation in future studies. Finally, although self-report MSE has been widely used for health behavior surveillance in the United States,⁴ Canada,⁵ and other countries,^{9,10} the validity of the MSE item is currently unclear.

4.2. Practical implications

There is an urgent need for MSE interventions in China in order to improve the physical fitness of school-aged children.¹⁴ Our study provides preliminary evidence regarding socio-ecological factors that may benefit MSE participation among Chinese children and adolescents. Some of the important public health implications derived from our study are as follows:

(1) MSE participation among female, high-school-aged children and adolescents, and low socioeconomic status populations should be increased, which might be accomplished by providing these groups with more MSE resources. Meanwhile, schools, families, and communities should be encouraged to provide more social support in an effort to weaken negative stereotypes associated with MSE (e.g., excessive muscle gain, high injury risk, and hyper-masculine settings). Affordable and accessible MSE facilities (e.g., fitness centers) should be provided in order to promote MSE in communities with different socioeconomic characteristics.³⁸

(2) Instilling regular MSE participation requires encouragement from professionals with MSE knowledge and skills. With regard to children and adolescents, physical education teachers and coaches are important in that they have skills in prescribing and teaching MSE. Therefore, these professionals should provide children and adolescents with MSE knowledge and skills that will lead to motor skill learning and organized sport participation.

(3) Parents who develop a positive understanding of MSE should participate in parent–child campaigns related to MSE,³⁹ thus helping their children achieve the recommended MSE levels. It is recommended that mass media campaigns regularly and widely disseminate information on the importance of MSE for health to the public, especially to parents and guardians. Meanwhile, increasing available facilities and establishing attractive spaces for MSE are requisites for both families and communities. Such improvements would provide more opportunities for parent–child campaigns related to MSE.

5. Conclusion

The prevalence of meeting the MSE recommendations among Chinese children and adolescents aged 9–17 years was relatively low compared to children and adolescents in developed countries. Multiple factors at the demographic, behavioral, psychological, and sociocultural levels significantly influence the participation of Chinese children and adolescents in MSE. Although there are vast sociocultural and economic differences between China and developed countries, most of the significant factors are similar, including sex, family income, parental education level, MVPA, and peer and parental support. Additionally, we observed that high school students were less likely to meet the MSE recommendations than that among 4th–6th graders and 7th–9th graders. Furthermore, children and adolescents with high exercise intention, proficiency in a higher number of sports, and a high parental MSE participation level were more likely to meet the MSE recommendations.

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Authors' contributions

FX, ZZ, and YT conceived the study design, collected and analyzed data, and drafted the manuscript; SC participated in the design of the study, provided critical feedback, and edited the manuscript; HC, XH, XM, KL, YL, LW, YC, and AC assisted in revising the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

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