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Physical activity and mental health in Chinese high school students: a cross-sectional study

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Adolescent physical activity (PA) is essential for mental health. However, the declining PA levels amongst this group pose global challenges. This study examines the relationship between PA and mental health amongst 1668 Chinese high school students, focusing on gender and grade-level differences. Only 30.9% of students met the recommended 60 min of daily moderate-to-vigorous PA (MVPA), with boys showing a significantly higher compliance rate than girls (44.2% vs. 25.2%, $P < 0.001$). MVPA compliance was linked to better mental health, as compliant students had a lower mental health detection rate (43.6%) compared with non-compliant peers (56.4%, $P < 0.001$). The grade 11 students were at the highest risk of mental health issues (OR = 2.421, 95% CI: 1.893–3.096 and $P < 0.001$), whilst being female (OR = 0.630, 95% CI: 0.502–0.791 and $P < 0.001$). Meanwhile, MVPA non-compliance (OR = 0.792, 95% CI: 0.736–0.851 and $P = 0.008$) were additional risk factors. Poorer mental health correlated with reduced time in vigorous PA and increased time in low-intensity activities ($P = 0.001$). These findings highlight the low PA levels and significant mental health risks amongst adolescents, particularly girls and grade 11 students. Targeted interventions promoting PA, time management and mental health support are critical.

Keywords Proactive health, Physical activity, Mental health, High school students, Cross-sectional study, Gender differences, Grade-level impact

Adolescents' physical and mental health challenges have become a critical focus of global concern amidst the accelerating pace of modern life and increasing academic stress. In particular, high school students aged 15–18 years old are at a pivotal stage of physical growth and value formation, where their physical and mental well-being not only influence academic performance but also exert profound effects on long-term developmental outcomes[1]. This age group is also experiencing significant physical growth, psychological changes, and emotional development, making them particularly vulnerable to the negative effects of insufficient physical activity and mental health issues[2,3]. Consequently, this period of life is particularly sensitive to these influences, making it a crucial time for intervention and support. However, the high demands of academic workloads and fast-paced lifestyles have resulted in insufficient levels of physical activity (PA) amongst a number of students, further aggravating mental health issues, such as anxiety, depression and emotional dysregulation[4,5].

According to the World Health Organization, nearly 80% of adolescents worldwide are not sufficiently active, which directly impacts their mental well-being[6]. In China, recent surveys show that a considerable number of high school students experience mental health problems, with anxiety and depression being particularly prevalent. A meta-analysis of 17 studies, which included a total sample of 63,060 adolescents, found that the detection rate of psychological sub-health among high school students was 18.99%, the highest among all educational levels[7].

PA has been consistently identified as a key health-promoting behaviour with significant implications for mental health. Numerous studies have established a negative dose–response relationship between the PA levels and the prevalence of mental health problems, with higher levels of PA corresponding to reduced risks of anxiety and depression[8–10]. Despite the importance of PA, the decline in PA levels during adolescence has become a pervasive global phenomenon, with serious implications for immediate health and long-term quality of life[11,12]. This decline underscores the critical need for timely and effective intervention strategies during adolescence, a period marked by dynamic physical and psychological transitions.

In this context, the concept of proactive health has gained prominence as an innovative and effective strategy for addressing adolescent health challenges. Proactive health emphasises active individual participation in health management, combining preventive and early intervention measures to improve overall well-being and

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shift away from traditional, reactive health models[13]. The 'Healthy China 2030' plan has further reinforced the adoption of proactive health approaches within China, offering significant opportunities to integrate this framework into adolescent health promotion efforts[14,15].

On this basis, this study aims to investigate the relationship between PA levels and mental health amongst Chinese high school students aged 15–18 years old. Specifically, this study seeks to: (1) analyse the associations between PA levels and mental health outcomes; (2) examine the interaction effects of gender and grade level on PA and mental health; and (3) provide evidence-based recommendations for school- and family-based health interventions. This study seeks to advance understanding of adolescent PA and mental health dynamics within the framework of proactive health strategies utilising a cross-sectional study design. The findings aim to contribute to the development of targeted interventions that align with the broader objectives of proactive health and the 'Healthy China 2030' agenda.

Methods

Study design and participants

This cross-sectional study was conducted between September and November 2024 in a high school in Xiamen, Fujian Province, China. The school comprised 60 classes (20 classes per grade across Grades 10–12), with each class having up to 60 students.

Sampling method

Using a stratified cluster random sampling approach: (1) Stratification: Classes were divided into three strata by grade level (Grade 10: 15–16 years, Grade 11: 16–17 years, Grade 12: 17–18 years); (2) Cluster sampling: From each stratum, 10 classes were randomly selected via computer-generated random numbers, totaling 30 classes (10 classes × 3 grades).

All students in the sampled classes ($n = 1{,}800$) were invited to participate.

Inclusion criteria

(1) Enrolled in Grades 10–12; (2) Aged 15–18 years; 3) No physical disabilities preventing PA participation.

Exclusion criteria

(1) Incomplete questionnaires; (2) Refusal to provide informed consent.

Ethical approval and consent to participate

This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and relevant guidelines and regulations. The research protocol was reviewed and approved by the Ethics Committee of Jimei University. Written informed consent was obtained from all participants prior to the study. For participants under the age of 18, informed consent was also obtained from their legal guardians. All participants were assured that their data would remain confidential and used only for research purposes.

Measures

Demographic information

A demographic questionnaire collected gender, age, socioeconomic status (SES), and parental education levels. Height and weight data were obtained from the school's annual National Student Physical Fitness and Health Test, conducted in strict compliance with the National Student Physical Health Standards (2014 Revision)[16]. Measurements followed standardized protocols: students were barefoot, wearing light clothing, with height measured to the nearest 0.1 cm using a wall-mounted stadiometer (RGZ-160, China) and weight recorded to the nearest 0.1 kg using a calibrated digital scale (RGT-140, China). Students additionally self-reported their perceived physical fitness and knowledge of psychological health resources. Perceived physical fitness was included as a demographic characteristic as it reflects students' subjective evaluation of their physical health, which may influence their physical activity levels and mental health outcomes. This self-assessment is an important indicator of how students perceive their own physical capabilities and can provide insight into their overall well-being.

Mental health assessment

The Mental Health Scale for Middle School Students (MSSMHS)[17], developed by Wang Jisheng, was used to assess psychological health. This 60-item scale evaluates 10 dimensions: obsessive-compulsive symptoms, paranoia, hostility, interpersonal sensitivity, depression, anxiety, academic stress, maladjustment, emotional instability, and psychological imbalance. Each item is scored on a 5-point Likert scale (1 = "never" to 5 = "always"). Dimension scores are calculated as the sum of six items per dimension (range: 6–30), with severity classified as follows: 1.0–1.99 (no symptoms), 2.0–2.99 (mild), 3.0–3.99 (moderate), 4.0–4.99 (severe), and 5.0 (extreme). A global mental health score was derived by dividing the total score by 60 (range: 1.0–5.0), where higher scores indicate poorer mental health. The MSSMHS has demonstrated good reliability and validity, with a Cronbach's alpha coefficient of 0.85 in the original validation study[17].

PA assessment

Physical activity (PA) was measured using the Chinese Questionnaire on Physical Activity Levels for Children and Adolescents Aged 7–18[18]. This instrument includes 27 predefined activities and 3 self-reported items, covering four domains: (1) transportation PA (e.g., walking, cycling), (2) recreational PA (e.g., outdoor games, jump rope), (3) household PA (e.g., sweeping, dishwashing), and (4) sports PA (e.g., basketball, running). Participants recalled the type, duration, and perceived intensity of activities over the past week. For each PA

item, the activity time was calculated as the product of the number of times the activity was performed and the average duration per session. The intensity of each PA item was determined based on the Compendium of Physical Activities[19]. Activity time for low-intensity, moderate-intensity, and vigorous-intensity activities was then separately accumulated to derive the corresponding PA time for each intensity level. Total PA (TPA) and moderate-to-vigorous PA (MVPA) were calculated based on the sum of activity times for the respective intensity categories. Compliance with PA guidelines was defined as engaging in ≥60 min/day of MVPA according to WHO guidelines[20]. The questionnaire showed acceptable reliability (Cronbach's α: 0.70 for MVPA, 0.72 for TPA; test-retest $r = 0.74–0.78$) and validity (accelerometer correlation $r = 0.69$, $P < 0.01$).

Data collection

Paper-based questionnaires were administered in classroom settings under the supervision of homeroom teachers during a 40-minute class period. Teachers ensured anonymity by collecting questionnaires in sealed envelopes and prohibiting personal identifiers.

Statistical analysis

The data were analysed using SPSS 26.0 software. Descriptive statistics were reported as means ± standard deviations (M ± SD) for continuous variables and as percentages for categorical variables. The PA time across different intensities (LPA, MPA and VPA) was presented as medians and interquartile ranges (M [P25, P75]) due to the skewed distribution of the data. The following statistical methods were applied:

(1) Normality testing: Conducted using the Kolmogorov–Smirnov (K–S) test.
(2) Non-parametric tests: The differences in PA and mental health dimensions between groups were assessed using the Kruskal–Wallis H test (for multiple group comparisons) and Wilcoxon rank-sum tests (for pair-wise comparisons).
(3) Chi-square tests: Used to compare compliance rates and psychological health detection rates between different subgroups.
(4) Logistic regression analysis: Applied to evaluate the association between demographic factors, PA compliance and mental health status. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Statistical significance was set at $P < 0.05$.

Results

Demographicc

Out of the 1800 questionnaires distributed, a total of 1668 valid responses were collected after data cleaning, resulting in an effective response rate of 92.7%. Among the valid responses, 507 were from boys (30.4%) and 1161 from girls (69.6%), with participants aged between 15 and 18 years. The analysis of the demographic characteristics of the 1668 students provides a detailed overview of the study cohort, including gender distribution, grade level, family economic status, parents' educational background, and students' self-assessed physical activity capabilities. The specific data are presented in Table 1.

The sample included 507 male students (30%) and 1161 female students (70%), with a significantly higher proportion of females. In terms of grade distribution, the proportions of participants across grades were relatively balanced: 34.7% in grade 10, 31.7% in grade 11 and 33.4% in grade 12. Additionally, most students' families were classified as having an 'average' economic status (68.3%), and majority of parents had attained either middle school or high school education.

Descriptive statistics of mental health dimensions

The results showed that academic stress scored the highest (mean = 2.36 ± 0.99), followed by emotional imbalance (mean = 2.18 ± 0.82) and anxiety (mean = 2.17 ± 0.99). These findings indicated that students typically face significant academic stress, alongside challenges in emotional regulation and psychological adjustment. Furthermore, obsessive-compulsive symptoms (mean = 2.14 ± 0.74) and depression (mean = 2.00 ± 0.88) were relatively prominent. The other dimensions, such as paranoia, hostility, and interpersonal sensitivity, showed lower scores. The distribution of severity levels and the scores for each mental health factor are visualized in Figs. 1 and 2, respectively.

Figure 1 highlights that academic stress, emotional imbalance and anxiety are the most severe factors amongst students. Figure 2 shows that the score distributions for academic stress, emotional imbalance and anxiety are more concentrated with higher medians.

Gender differences in PA time

Significant gender differences in PA time can be observed amongst adolescents. Overall, males demonstrated significantly higher levels of MVPA than females, with the median daily MVPA time for males at 35.7 min/day, compared with 24.3 min/day for females. In terms of PA types, males spent more time on sports and transportation-related activities, whereas females slightly engaged more in household activities. The specific statistics are presented in Table 2, and the distributions of PA time for each gender are visualised in Fig. 3.

Figure 3 illustrates that males had a wider range of PA distribution in MVPA and sports-related activities, whereas females concentrated more on low-intensity and household activities.

PA and mental health by mental health status

PA time significantly varied by students' mental health status (classified as normal, mild, moderate or severe). The students with better mental health (normal or mild mental health issues) had significantly higher MVPA and total PA (TPA) time than those with poorer mental health (moderate or severe issues). Additionally, the

Category	Option	Number	Percentage (%)	Mean ± SD
Grade	Grade 10 (male: 243, female: 337)	580	34.7	
	Grade 11 (male: 116, female: 412)	528	31.7	
	Grade 12 (male: 148, female: 412)	560	33.4	
Gender	Male	507	30	
	Female	1161	70	
Height				165.86 ± 8.22
Weight				56.30 ± 10.56
BMI				20.38 ± 2.95
Perceived physical fitness	Poor (limited ability to perform physical activity)	256	15.3	
	Average (adequate ability)	780	46.8	
	Good (strong ability)	460	27.6	
	Very good (excellent ability)	116	7	
	Excellent (outstanding ability)	56	3.3	
Family economic status	Poor (low income)	80	4.8	
	Average (middle income)	1140	68.3	
	Good (above average income)	428	25.7	
	Affluent (high income)	20	1.2	
Father's educational level	Middle school or below	560	33.6	
	High school (or vocational)	544	32.6	
	College (or associate degree)	520	31.2	
	Master's degree or above	44	2.6	
Mother's educational level	Middle school or below	804	48.1	
	High school (or vocational)	488	29.3	
	College (or associate degree)	368	22.1	
	Master's degree or above	8	0.5	
Psychological counselling resources	Available	1620	97.1	
	Not available	48	2.9	
Awareness of mental health hotline	Yes	552	33.1	
	No	1116	66.9	

Table 1. Basic demographic characteristics of the study participants.

students with poorer mental health spent less time in vigorous PA (VPA) and more time in low-intensity PA (LPA). The detailed statistics are presented in Table 3, and the distribution of PA time by mental health status is visualised in Fig. 4.

Figure 4 illustrates that the students with poorer mental health show decreased time spent on high-intensity activities and increased time on low-intensity activities.

PA compliance and mental health

The relationship between compliance with PA guidelines (MVPA ≥ 60 min/day) and mental health was further analysed. The results showed that only 30.9% of the students met the guideline for MVPA. The compliance rate was significantly higher for males (44.2%) than for females (25.2%). Additionally, mental health problems were negatively associated with PA compliance: the mental health detection rate was 43.6% amongst students who met the MVPA guidelines compared with 56.4% amongst those who did not. The detailed data are provided in Table 4, and the distributions of MVPA compliance and mental health detection rates are shown in Fig. 5.

Figure 5 illustrates that insufficient PA is potentially associated with a higher detection rate of mental health problems.

Logistic regression analysis of the factors affecting mental health

Logistic regression analysis was conducted using gender, grade level, MVPA compliance, and knowledge of school mental health hotlines as independent variables, with mental health status as the dependent variable. The reference categories for each variable are indicated in Table 5. The results shown in Table 5 indicated that being female, being in grade 11 and non-compliance with the MVPA guidelines were significantly associated with poorer mental health, whereas awareness of school mental health hotlines did not show significant effects.

(1) Male students exhibited better mental health than female students, with a significantly lower risk of mental health issues (OR = 0.630, 95% CI: 0.502–0.791 and $P < 0.001$).
(2) Students in grade 11 had a significantly higher risk of mental health problems compared to grade 12 students (OR = 2.421, 95% CI: 1.893–3.096 and $P < 0.001$). No significant difference was observed between grades 10 and 12 (OR = 1.215, 95% CI: 0.951–1.553 and $P = 0.119$).

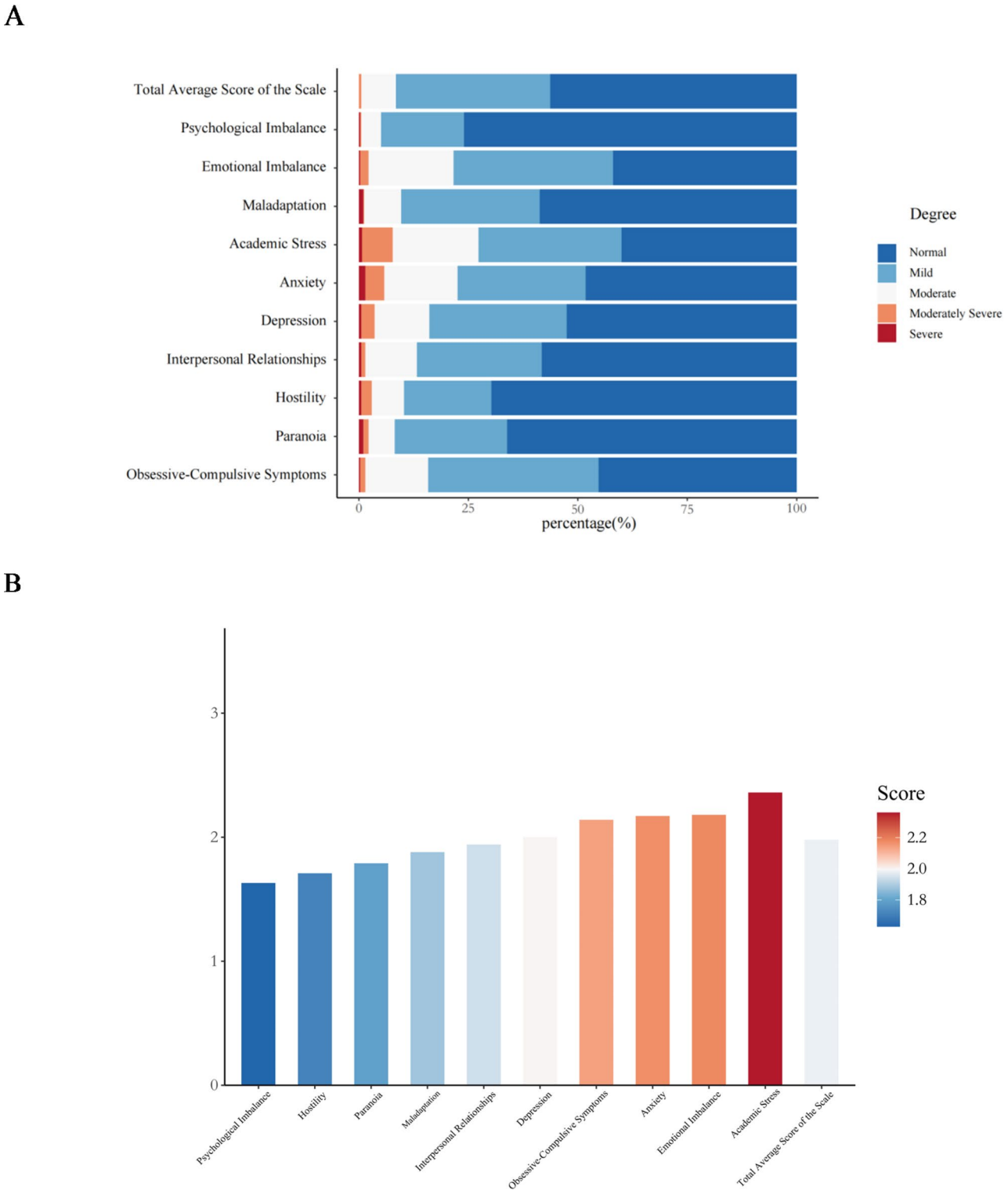

Fig. 1. Distribution of mental health factors. (**A**) Distribution of the severity levels for each mental health factor. (**B**) Score distribution for each mental health factor.

(3) Students who did not meet the daily 60 min MVPA guidelines were significantly more likely to experience mental health problems (OR = 0.792, 95% CI: 0.736–0.851 and $P = 0.008$).
(4) Awareness of the school mental health hotlines did not have a statistically significant effect on mental health (OR = 0.625, 95% CI: 0.346–1.131 and $P = 0.121$).

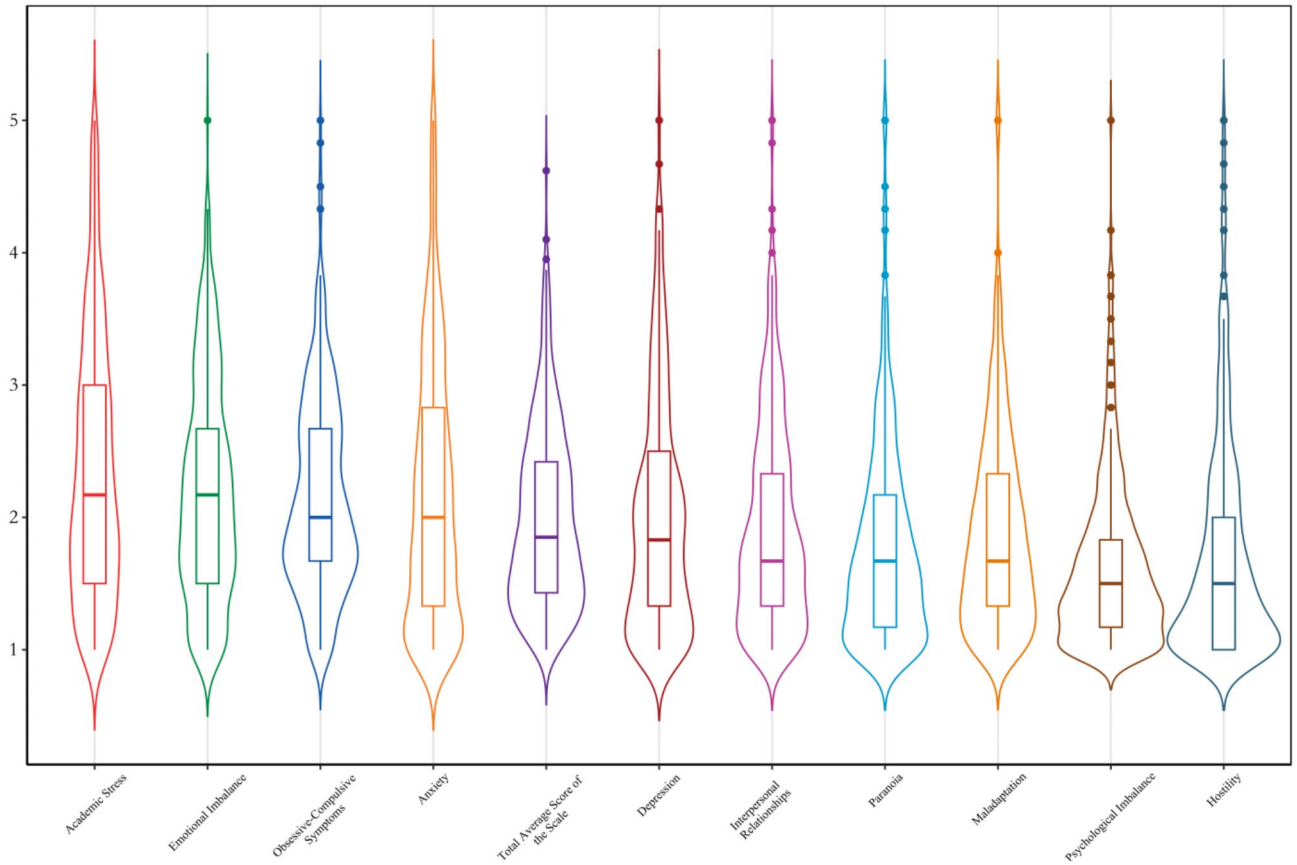

Fig. 2. Distribution of the Mental Health Factor Scores.

Gender	Sample size	Statistics					M (P25, P75) min/day				
			LPA	MPA	VPA	MVPA	TPA	Transportation PA	Household PA	Recreational PA	Sports PA
Male	507		10.0 (4.3,20.0)	15.7 (8.6,32.1)	13.9 (5.7,32.9)	35.7 (18.6,66.4)	49.3 (29.3,84.3)	20.0 (11.4,32.9)	4.3 (0,8.6)	0 (0,0)	13.6 (2.9,41.4)
Female	1161		10.7 (3.6,19.3)	13.6 (5.7,24.3)	7.1 (3.6,14.3)	24.3 (13.1,38.6)	37.8 (22.9,60.0)	17.1 (8.6,27.9)	4.3 (0.7,8.6)	0 (0,4.3)	8.6 (0.7,18.6)
		Z	−0.402	−3.958	−9.049	−9.210	−7.027	−3.762	−0.731	−3.005	−6.839
		P	0.688	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.464	0.003	< 0.001

Table 2. Comparison of the time spent on the different intensities and types of PA amongst adolescents by gender.

Discussion

This study provides a comprehensive examination of the intricate relationships between PA and mental health amongst Chinese high school students, uncovering the significant roles of gender, grade level, MVPA compliance and awareness of mental health resources in shaping psychological well-being. Gender was found to be an important factor, with boys demonstrating better mental health outcomes and engaging in significantly more MVPA than girls. Girls showed lower PA compliance rates, sports participation levels, and mental health scores. These findings suggest that adolescent girls may be more vulnerable to mental health issues, potentially due to physiological and psychosocial factors, such as heightened emotional sensitivity and stress[21,22]. Moreover, existing studies highlight marked gender differences in PA and sedentary behavioural patterns, with boys exhibiting higher baseline MVPA levels but steeper declines over time, whilst girls maintain consistently lower levels and smaller variations[23]. These disparities underscore the necessity of gender-sensitive interventions that align with the proactive health paradigm, emphasising behavioural self-management and preventive strategies. Tailored interventions for girls that address these barriers may effectively enhance their PA participation and improve their mental health outcomes[24,25].

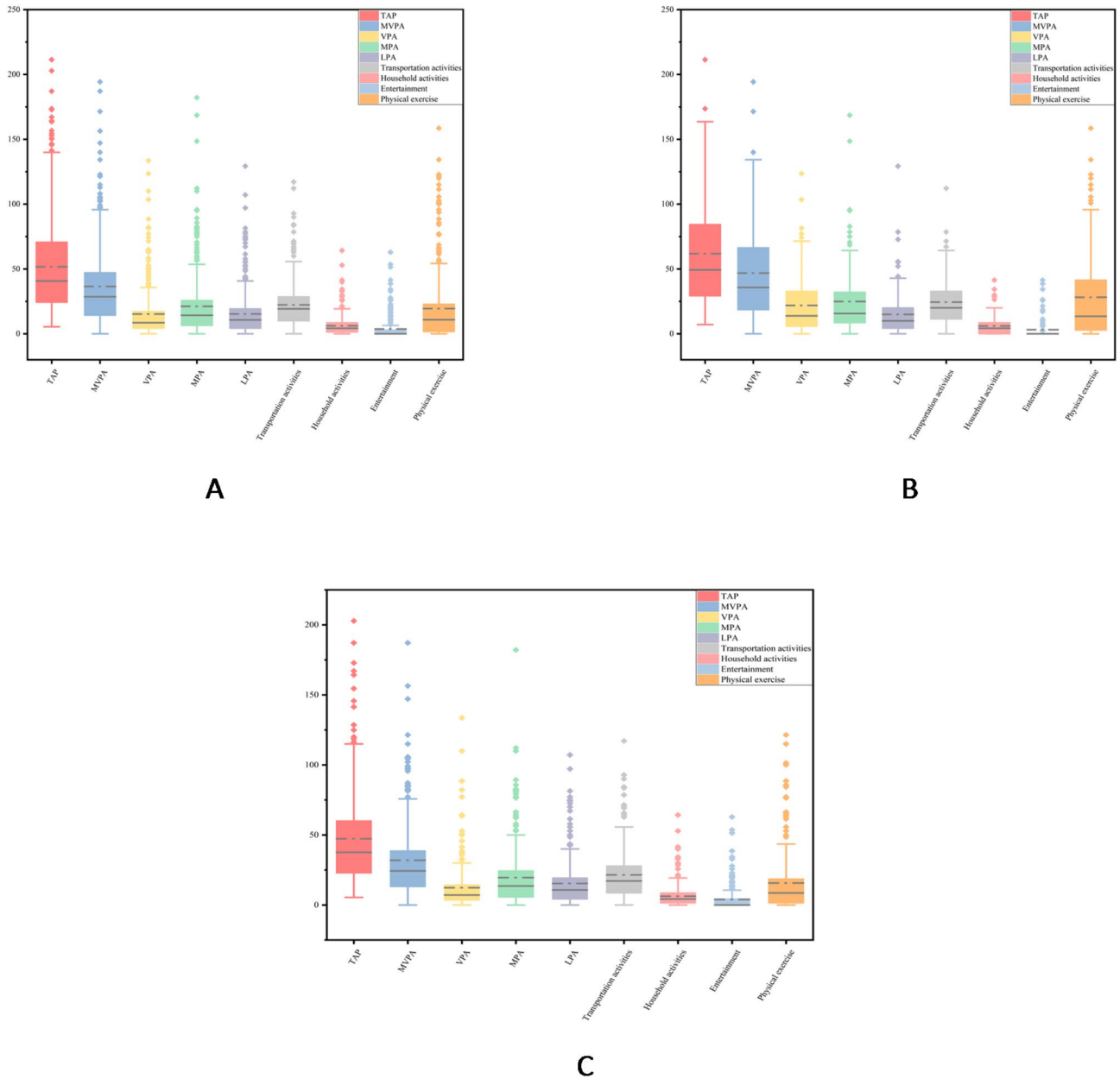

Fig. 3. Distribution of the time spent on the different intensities and types of PA amongst adolescents by gender. (**A**) Distribution of the time spent on the different intensity levels of PA and various types of PA in the overall study population. (**B**) Distribution of time spent on different intensity levels of PA and various types of PA amongst male participants. (**C**) Distribution of the time spent on the different intensity levels of PA and various types of PA amongst female participants.

Grade level also exerts a profound influence on mental health, with grade 11 students identified as facing a significantly higher risk of psychological distress compared to their grade 10 and 12 peers. This can be attributed to the unique 'sandwich grade' effect, where students experience heightened academic stress combined with insufficient psychological and social support[26]. Grade 10 students generally face lower academic pressure as they adapt to high school life and retain a sense of optimism about their future. However, Grade 11 students encounter a significant transition. They begin preparing for major exams such as the Gaokao, which often causes them to confront the gap between their idealized expectations and the realities of their academic situation. This can lead to stress and uncertainty about their future academic and career choices. Many students at this stage report feeling unsure about their paths, which exacerbates psychological strain. In contrast, Grade 12 students, while still under the pressure of impending exams, often have a clearer sense of direction. By this stage, students are typically more confident in their future plans, whether for further study or entering the workforce. This greater sense of preparedness helps alleviate some of the anxiety that is more pronounced in Grade 11.

Gender	Group	*N*	Statistic	M (P25, P75) min/day								
				LPA	MPA	VPA	MVPA	TPA	Transportation PA	Household PA	Recreational PA	Sports PA
Male	Normal	328		10.0 (4.3,20.0)	15.7 (8.6,31.4)	13.6 (5.7,27.9)	35.3 (19.3,68.6)	48.0 (29.3,87.9)	21.4 (11.4,32.9)	3.9 (0,8.6)	0 (0,0)	16.8 (3.1,41.4)
	Mild	144		9.6 (3.2,15.0)	17.1 (6.4,35.9)	14.1 (6.4,35.4)	39.6 (18.2,66.3)	58.2 (30.0,76.3)	18.2 (8.6,31.6)	4.3 (0.9,9.1)	0 (0,6.3)	13.9 (0,37.0)
	Moderate	32		17.9 (7.7,32.7)	13.2 (6.1,31.6)	12.9 (6.1,49.3)	36.0 (19.3,61.8)	63.1 (33.8,89.3)	21.4 (12.1,44.3)	4.3 (0,24.3)	0 (0,10.4)	7.9 (5.1,34.6)
	Moderately severe	3		0 (0,0)	11.4 (11.4,11.4)	2.9 (2.9,2.9)	14.3 (14.3,14.3)	14.3 (14.3,14.3)	14.3 (14.3,14.3)	0 (0,0)	0 (0,0)	0 (0,0)
			H	17.194	2.096	6.248	0.188	0.040	5.280	7.536	15.117	8.827
			P	< 0.001	0.533	0.100	0.188	0.040	0.152	0.057	0.002	0.032
Female	Normal	612		10.0 (4.3,19.3)	13.6 (5.7,22.9)	7.1 (2.9,14.3)	22.1 (13.6,38.6)	35.7 (21.4,59.3)	17.1 (8.6,27.9)	4.3 (1.4,7.9)	0 (0,4.3)	8.6 (0,18.6)
	Mild	444		12.9 (2.9,21.4)	11.4 (5.7,25.7)	7.9 (3.6,14.3)	26.3 (11.9,37.1)	38.6 (22.9,56.4)	19.4 (10.0,28.6)	3.6 (0,8.6)	0 (0,2.9)	8.6 (1.4,20.0)
	Moderate	100		8.6 (2.9,16.4)	20.7 (11.4,35.0)	8.6 (5.0,12.9)	32.9 (23.6,54.3)	42.1 (32.9,80.0)	17.1 (6.4,27.1)	4.3 (0.7,11.4)	0 (0,7.1)	15.7 (0,26.9)
	Moderately severe	5		8.6 (4.3,8.6)	3.9 (3.9,7.6)	0 (0,1.4)	3.9 (3.9,9.1)	12.4 (12.4,13.4)	7.9 (7.9,11.1)	2.9 (1.4,2.9)	0 (0,0)	1.7 (0.9,1.7)
			H	2.784	23.430	12.902	27.548	18.256	5.613	2.734	10.461	9.067
			P	0.426	< 0.001	0.005	< 0.001	< 0.001	0.132	0.434	0.015	0.028
Total	Normal	940		10.0 (4.3,19.3)	14.3 (6.4,24.3)	8.6 (3.6,20.0)	25.7 (15.7,47.1)	40.7 (22.9,71.4)	20.0 (10.0,31.4)	4.3 (0.9,7.9)	0 (0,2.9)	11.4 (1.4,25.0)
	Mild	588		11.6 (2.9,20.0)	13.6 (5.7,26.0)	8.9 (4.3,17.1)	29.3 (12.9,45.4)	40.0 (24.3,64.3)	19.3 (10.0,28.6)	4.3 (0.7,8.6)	0 (0,2.9)	10.0 (1.1,22.9)
	Moderate	132		10.0 (5.7,19.3)	18.6 (10.0,35.0)	8.6 (5.7,14.3)	32.9 (21.4,56.4)	44.3 (32.9,80.0)	17.1 (9.3,28.6)	4.3 (0.0,11.4)	0 (0,7.1)	10.0 (4.3,26.9)
	Moderately severe	8		4.3 (0,8.6)	7.6 (3.9,11.4)	1.4 (0,2.9)	9.1 (3.9,14.3)	13.4 (12.4,14.3)	11.1 (7.9,14.3)	1.4 (0,2.9)	0 (0,0)	0.9 (0,1.7)
			H	6.145	15.880	14.752	23.016	23.225	4.039	6.268	18.088	11.174
			P	0.105	0.001	0.002	< 0.001	< 0.001	0.257	0.099	< 0.001	0.011

Table 3. Distribution of the time spent on the different intensities and types of PA amongst adolescents with varying mental health levels.

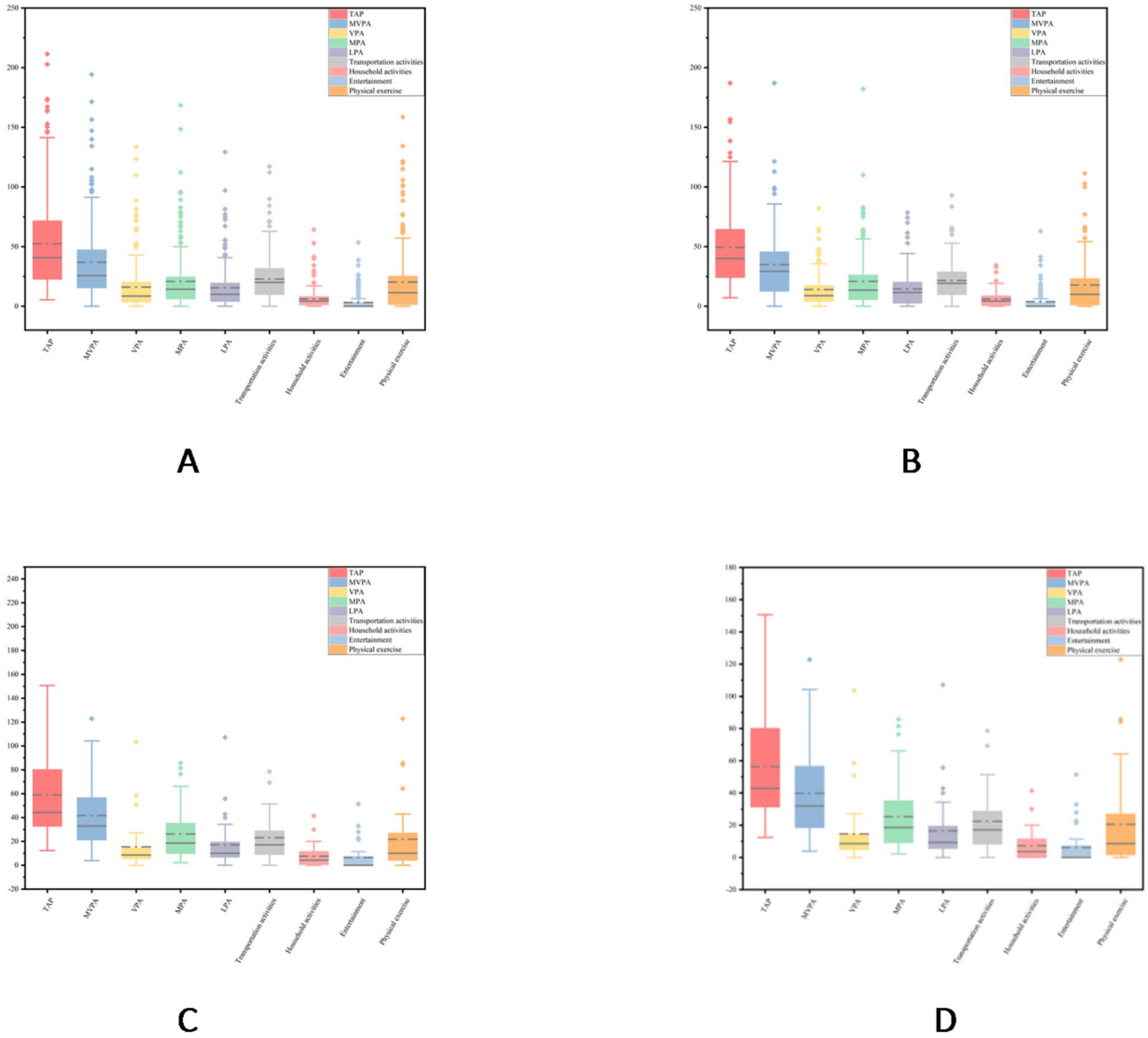

Fig. 4. Distribution of the time spent on the different intensities and types of PA amongst adolescents with varying levels of mental health. (**A**) Boxplot showing the distribution of time spent on the different intensities and types of PA amongst adolescents with normal mental health. (**B**) Boxplot showing the distribution of the time spent on the different intensities and types of PA amongst adolescents with mild mental health issues. (**C**) Boxplot showing the distribution of the time spent on the different intensities and types of PA amongst adolescents with moderate mental health issues. (**D**) Boxplot showing the distribution of the time spent on the different intensities and types of PA amongst adolescents with moderate to severe mental health issues. Considering the limited sample size of only eight participants with severe mental health issues, a separate boxplot for this group could not be created. Instead, Figure D combines data from adolescents with moderate and severe mental health issues.

Gender	MVPA compliance rate				Detection rate of mental health issues			
	MVPA < 60	MVPA ≥ 60	X	P	MSSMHS total score ≥ 2	MSSMHS total score < 2	X	P
	Non-compliant N(%)	Compliant N (%)			Healthy N (%)	Unhealthy N (%)		
Male	283 (55.8%)	224 (44.2%)	59.82	< 0.001	179 (35.3)	328 (64.7)	20.595	< 0.001
Female	869 (74.8%)	292 (25.2%)			549 (47.3)	612 (52.7)		
Total	1252 (69.1%)	516 (30.9%)			728 (43.6)	940 (56.4)		

Table 4. Compliance rate of the PA guidelines and detection rate of mental health issues.

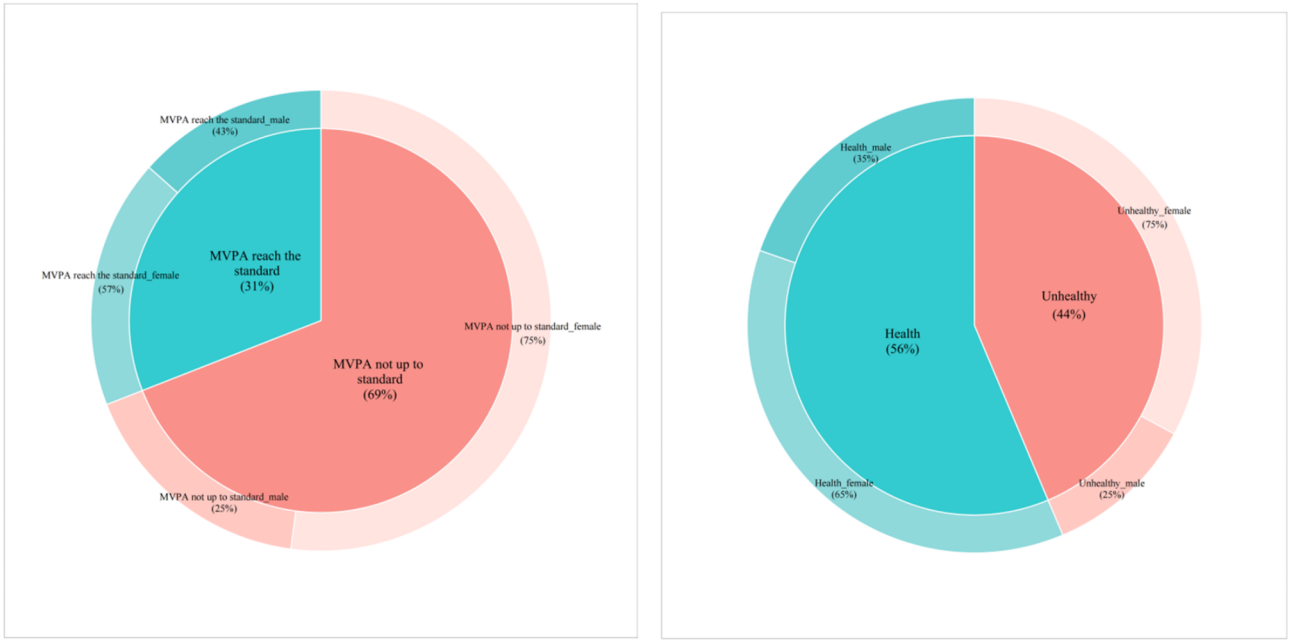

Fig. 5. Distribution of the MVPA compliance and detection rates of mental health issues. (**A**) Distribution and compliance rate of MVPA. (**B**) Distribution and detection rate of mental health issues.

Variables	B value	Standard error	*P*	OR (95% CI)
Male (compared to female)	−0.462	0.116	< 0.001	0.630 (0.502–0.791)
Grade (compared with grade 12)				
Grade 10	0.195	0.125	0.119	1.215 (0.951–1.553)
Grade 11	0.884	0.125	< 0.001	2.421 (1.893–3.096)
MVPA compliance (compared with MVPA < 60 min)	0.058	0.112	0.008	0.792 (0.736–0.851)
Awareness of the school mental health hotline (compared with unaware)	−0.47	0.303	0.121	0.625 (0.346–1.131)

Table 5. Logistic regression analysis of the factors associated with mental health.

Furthermore, Grade 12 students have more experience managing academic and life pressures, which contributes to better psychological adjustment[27].

To support these students, it is essential to recognize the distinct psychological challenges faced by Grade 11 students. Tailored interventions, including stress management programs and mental health support, can help mitigate the unique pressures they experience, promoting better mental health outcomes[24,25].

The protective effects of MVPA compliance on mental health are demonstrated in this study. The students who met the recommended 60 min of daily MVPA exhibited significantly better mental health compared with their non-compliant peers. These findings align with previous research indicating that regular MVPA alleviates anxiety, reduces depression and enhances psychological resilience and social connectedness[22]. Visier-Alfonso et al.[28] and Chu et al.[29] indicated that consistent engagement in MVPA during adolescence not only fosters mental health but also indirectly enhances academic performance by improving executive functions, cognitive flexibility and social interaction. However, the low MVPA compliance rate observed in this study—only 30.9% of the students met the daily recommendation—highlights a pervasive lack of sufficient PA amongst high school students, particularly those in grade 11. This insufficiency likely compounds students' mental health vulnerabilities, as supported by prior findings on the positive association between MVPA and mental health[24,25].

Furthermore, this study corroborates the bidirectional relationship between PA and mental health, wherein PA promotes psychological well-being, and better mental health facilitates greater PA engagement. The students with poorer mental health are more likely to engage in low-intensity activities and exhibited reduced participation in high-intensity PA. De Meester et al.[24] and Khodaverdi et al.[30] underscored the influence of actual and perceived motor competence on adolescents' motivation to engage in PA and their psychological well-being.

Several targeted recommendations are proposed based on these findings to enhance the PA levels and mental health outcomes amongst high school students. First, greater attention must be directed toward improving girls' mental health and participation in PA. Schools should design gender-sensitive programs, such as inclusive

sports courses, extracurricular sports clubs and community-based initiatives, to encourage girls' engagement in physical activities[31]. Additionally, implementing mental health education and peer-support programs could help girls better manage academic stress and psychosocial challenges[32]. Efforts to improve girls' perceived motor competence (PMC) are particularly critical, as increased PMC has been shown to significantly boost sports participation and mental health outcomes[30].

Tiered intervention strategies should be developed to address the elevated mental health risks faced by grade 11 students. Schools can offer stress management training, time management workshops and mental health seminars tailored to the specific needs of grade 11 students. In terms of PA, short, high-impact interventions, such as high-intensity interval training or 10–15 min brisk walking and stretching sessions, have been demonstrated to significantly increase MVPA compliance whilst improving mental health outcomes[33,34].

Promoting MVPA compliance is a critical step in safeguarding mental health. Schools should optimise their physical education curricula to ensure that sufficient time is allocated to PA whilst also diversifying activities to include engaging options, such as basketball, soccer and running[35,36]. Families can play a complementary role by organising outdoor activities and participating in PA with their children, consistent with evidence that highlights the positive effect of family support on PA participation[37,38].

Reducing sedentary behaviour should also be prioritised as a key intervention strategy. Sedentary behaviour is negatively associated with mental health, and schools and families can implement measures to address this issue. For instance, schools can introduce short activity breaks during class periods, whilst families can limit screen time and encourage outdoor activities to promote healthier behavior[39].

Lastly, the promotion and utilization of mental health resources must be enhanced. Schools should take proactive measures to increase awareness and accessibility of these resources, such as organizing mental health campaigns and sharing case studies during counseling sessions. Additionally, a tiered and diverse PA intervention system should be established to accommodate students with varying mental health needs. For instance, students with poorer mental health can begin with low-intensity activities and gradually progress to higher-intensity exercises with structured guidance and motivational support. Such individualized approaches have been shown to significantly improve mental health outcomes[40].

Despite the contributions of this study, it has several limitations. First, the cross-sectional design of this study limits causal inferences, making longitudinal research essential to understand the long-term effects of PA on mental health and clarify underlying mechanisms. Second, the sample is drawn from a single high school in Xiamen, Fujian Province, limiting the generalizability of the findings to other regions or cultural contexts where PA and mental health patterns may differ. Third, PA measurements relied on self-reported questionnaires, which are subject to recall bias and may not fully capture actual PA levels. Moreover, potential confounding variables, such as SES, social support, dietary habits and sleep quality, are not fully controlled, introducing potential bias. Lastly, although the MSSMHS is a reliable and valid tool, it lacks the capacity to capture more complex dimensions of mental health, such as well-being and life satisfaction, resulting in an incomplete assessment of psychological characteristics.

Future research should address these limitations by adopting longitudinal designs to explore the dynamic and causal relationships between PA and mental health. Expanding the sample to include diverse regions and schools would improve generalizability, whilst integrating objective PA measurement tools, such as accelerometers and heart rate monitors, could mitigate the limitations of self-reported data. Additionally, future studies should incorporate a wider range of confounding variables to develop a more comprehensive analytical framework and explore how factors, such as social support, family environment and sleep quality, mediate or moderate the relationship between PA and mental health.

Further research should also investigate broader mental health dimensions, such as well-being and life satisfaction, using multidimensional assessment tools to capture the full effect of PA. The interplay between gender and grade level requires deeper analysis, especially to understand the reasons for the decline in PA during late adolescence and its effect on mental health. Intervention studies in schools and communities are crucial to develop tailored PA programs for different genders and grade levels and assess their effectiveness in improving mental health outcomes[41]. Additionally, the incorporation of neuroscientific methods, such as EEG or neuroimaging tools, could provide valuable insights into the neurocognitive mechanisms linking PA to enhanced mental health outcomes[29].

In conclusion, this study underscores the significant association between PA and mental health amongst Chinese high school students, highlighting the protective role of sufficient MVPA and the urgent need for targeted interventions, particularly for girls and grade 11 students. The findings suggest that promoting PA, reducing sedentary behaviour and optimising extracurricular time management can enhance the PA levels and mental health, aligning with the principles of proactive health. Addressing the study's limitations and pursuing the proposed research directions will provide more comprehensive evidence to inform policy and practice, ultimately advancing adolescent well-being and contributing to the 'Healthy China 2030' initiative.

Data availability

The datasets generated and analyzed during the current study are available from the corresponding author, Xiangdong Wang, upon reasonable request.

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Author contributions

Z X and F Z contributed equally to this work. They were primarily responsible for study design, data collection, and initial data analysis. As co-corresponding authors, M S and X W jointly supervised the entire research process. M S provided critical input on methodology, statistical analysis, and manuscript preparation. X W revised the manuscript critically for important intellectual content and provided guidance throughout the study. All authors reviewed and approved the final version of the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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