

Relationship Burden or Health Resource? Synergistic Roles of Social Capital and Sports Participation in University Students' Depression Trajectories

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Abstract

Background: Social capital and sports participation are important influences on the mental health of university students, but how they jointly affect the dynamic development of depressive symptoms remains unclear. This study aimed to examine the longitudinal mediating role of sports participation in the association between social capital and depressive symptoms, and to identify heterogeneous developmental trajectories of depressive symptoms using latent class growth analysis.

Methods: A three-wave longitudinal survey was conducted among 1,622 university students (T1: 2016, T2: 2018, T3: 2020). Latent class growth analysis (LCGA) was used to identify developmental trajectories of depressive symptoms. Multinomial logistic regression was performed with T1 social capital and sports participation as predictors, using the “moderate-risk stable” group as the reference category. A three-wave mediation model was further constructed, controlling for T1 depressive symptoms, gender, age, and T1 sleep duration.

Results: LCGA identified three distinct trajectories of depressive symptoms: low-risk decreasing (68.3%), moderate-risk stable (26.7%), and high-risk increasing (5.1%). Multinomial logistic regression showed that T1 sports participation positively predicted belonging to the low-risk group (OR = 1.04), whereas T1 social capital (OR = 0.82) and age (OR = 0.91) negatively predicted low-risk group membership. None of the variables significantly distinguished the high-risk group from the moderate-risk group. Mediation analysis revealed an indirect effect of T1 social capital on T3 depressive symptoms via T2 sports participation of 0.03, with path coefficients indicating that higher social capital was associated with lower sports participation, which in turn was associated with more severe depressive symptoms.

Implications and Contribution: This study identifies three distinct depressive symptom trajectories among Chinese university students, revealing that social capital may paradoxically increase depression risk by reducing sports participation. Findings underscore the need for tiered mental health interventions and highlight the importance of balancing social engagement with physical activity to prevent depression.

1. Introduction

University students represent a critical population transitioning from late adolescence to early adulthood, a period characterized by multiple stressors including academic competition, interpersonal relationship restructuring, identity formation, and future career planning. This developmental stage renders them particularly vulnerable to psychological distress, especially depressive symptoms (Ibrahim et al., 2013). Globally, depression prevalence among university students has increased substantially, threatening not only individual academic achievement and personal development but also broader societal productivity (World Health Organization, 2017). In China, a national epidemiological study reported that the lifetime prevalence of major depressive disorder among young adults exceeds 5% (Huang et al., 2020); a more recent systematic review and meta-analysis of Chinese university students reported a summary prevalence of 34.70% (Liu et al., 2022), underscoring an urgent need for etiological research and evidence-based interventions.

Traditional variable-centered approaches have often conceptualized depression as a homogeneous phenomenon or focused exclusively on average population change. However, growing evidence indicates substantial individual heterogeneity in the onset, duration, and severity of depressive symptoms (Musliner et al., 2016; Nolen-Hoeksema and Watkins, 2011). While some individuals maintain consistently low symptoms, others experience

chronic elevated symptoms, and still others exhibit dynamic patterns of remission or worsening. Failure to account for such heterogeneity may obscure subgroup-specific risk and protective mechanisms, thereby undermining the precision of mental health interventions. Consequently, person-centered methods—such as Latent Class Growth Analysis (LCGA)—that identify subgroups following distinct developmental trajectories have gained increasing recognition (Muthén and Muthén, 2000). These approaches are particularly suited to inform tiered, tailored intervention strategies in university settings.

Among the myriad factors influencing depression trajectories, social determinants and health behaviors have drawn considerable research attention. Social capital—defined as resources embedded within social networks, encompassing trust, reciprocity norms, and social participation—has been widely acknowledged as a key social determinant of mental health (De Silva et al., 2005). According to social support theory, high social capital provides emotional support, instrumental assistance, and a sense of belonging, effectively buffering stress and reducing depression risk (Cohen and Wills, 1985). However, social capital may also entail negative consequences. In collectivist cultural contexts such as China, where interpersonal harmony and relationship maintenance are highly valued, the emphasis on social ties can paradoxically generate a “relationship burden” (Portes, 1998; Chen et al., 2025). This burden manifests as social comparison, excessive relational responsibility, and psychological strain, potentially transforming supportive networks into additional stressors—particularly for individuals already vulnerable to depression. An umbrella review of meta-analyses recently confirmed the push-and-pull of social connection in depression, highlighting both protective and risk-enhancing pathways (De Risio et al., 2024). A recent meta-analysis also unveiled a significant negative correlation between social support and depressive symptoms during the COVID-19 pandemic (Zhang et al., 2024). Recent longitudinal evidence in Chinese pregnant women confirmed that higher early-pregnancy social capital predicts more favorable depression trajectories (Chen et al., 2025), but whether this protective effect generalizes to university students—whose social networks undergo dramatic reorganization—remains unclear. Direct evidence among Chinese university students suggests that social capital, psychological resilience, and psychological distress are closely intertwined (Huang et al., 2020). Moreover, few studies have examined whether social capital can simultaneously exert opposing effects on different depression trajectory subgroups within the same population.

Sports participation has been robustly established as a protective factor for mental health. Meta-analytic evidence indicates that regular Sports participation effectively prevents and alleviates depressive symptoms (Schuch et al., 2018), with mechanisms spanning neurobiological (e.g., brain-derived neurotrophic factor release), psychological (e.g., enhanced self-efficacy, mastery experiences), and social (e.g., increased social interaction) pathways (Mikkelsen et al., 2017). Furthermore, Studies have shown that participating in two or more sports is associated with a lower risk of depressive symptoms (e.g., feeling sad or hopeless), suicidal ideation, and suicidal behaviors (Veliz, P., & Mutumba, M, 2023). Behavioral activation theory posits that depression is associated with reduced engagement in pleasurable activities; sports participation, as a paradigmatic positive behavior, may disrupt the depression-withdrawal cycle (Jacobson et al., 2001). Importantly, social capital and sports participation are interconnected: social networks can provide exercise companions, encouragement, and opportunities, thereby facilitating sustained Sports participation (Berkman et al., 2000). Conversely, time spent maintaining extensive social networks may displace Sports participation, a potential pathway that has received little empirical attention.

Despite these well-established bivariate associations, several critical research gaps persist. First, the vast majority of studies employ cross-sectional designs or focus on average change, failing to capture heterogeneous

depression trajectories and their differential associations with social capital and sports participation. Second, longitudinal investigations integrating all three constructs within a unified mediation framework remain scarce. Third, Chinese university students—a population undergoing unique sociocultural transitions (e.g., from family-centered to peer-centered networks, pressures of collectivist academic environments)—have received insufficient attention, and the culturally specific meaning of social capital (e.g., *guanxi*, *mianzi*) may produce relationships distinct from those in Western contexts, necessitating indigenous empirical validation (Liu et al., 2020; Zhang et al., 2010).

To address these gaps, the present study utilized three waves of nationally representative longitudinal data from the China Family Panel Studies (CFPS 2016–2020) with the following objectives: (1) to identify heterogeneous developmental trajectories of depressive symptoms among Chinese university students using LCGA; (2) to examine the predictive effects of baseline social capital and sports participation on trajectory class membership; and (3) to test the longitudinal mediating role of sports participation in the association between social capital and subsequent depressive symptoms. By integrating developmental, epidemiological, and health behavior perspectives, this study aims to advance etiological understanding of depression in Chinese university students and provide evidence-based guidance for tiered, culturally sensitive mental health interventions.

2. Methods

2.1. Study design and participants

The data for this study were obtained from the China Family Panel Studies (CFPS), a nationally representative, multidisciplinary longitudinal survey conducted by the Institute of Social Science Survey at Peking University (Xie et al., 2014). The CFPS employs a multistage probability sampling design proportional to population size, ensuring broad generalizability. We used three survey waves: 2016 (T1), 2018 (T2), and 2020 (T3). Inclusion criteria required participants to be enrolled as university students (including junior college, undergraduate, or postgraduate) at T1 and to have completed the core depression measure at all three waves. After data cleaning, the final analytic sample comprised 1,622 participants. The mean age at T1 was 20.35 years ($SD = 1.78$), with 48.3% males and 51.7% females.

The data used in this study are derived from the CFPS, with persistent identifier DOI:

<https://doi.org/10.18170/DVN/45LCSO>. All supporting data, documentation, and analysis files are publicly accessible via the CFPS data platform hosted by Peking University Open Research Data Platform. This study was conducted in accordance with the principles of the Declaration of Helsinki. The China Family Panel Studies (CFPS) was approved by the Biomedical Ethics Committee of Peking University, and written informed consent was obtained from all participants by the original survey team. For this secondary analysis of de-identified publicly available data, our institutional review board granted an exemption from further ethical review.

2.2. Measures

Depressive symptoms. Depressive symptoms were assessed longitudinally using the Chinese version of the 8-item Center for Epidemiologic Studies Depression Scale (CES-D-8; Radloff, 1977; Zhang et al., 2010). Each item asks about the frequency of a symptom experienced over the past week (e.g., “I felt depressed”), rated on a 4-point scale from 0 (“rarely or none of the time”) to 3 (“most or all of the time”). Total scores range from 0 to 24,

with higher scores indicating greater depressive symptom severity. The CES-D-8 has demonstrated satisfactory reliability and validity in Chinese populations. In the present study, Cronbach's α at T1 was 0.82.

Social capital. Social capital was operationalized as a composite indicator combining structural and cognitive dimensions, consistent with established frameworks (De Silva et al., 2005; Liu et al., 2020). Structural social capital was measured using two items: frequency of social/recreational activities with non-cohabiting relatives and with non-cohabiting friends. Cognitive social capital was assessed using items on generalized trust ("In general, do you agree that most people in this society can be trusted?") and institutional trust ("To what extent do you trust local government institutions?"). Item scores were standardized and averaged; higher scores indicate greater social capital. The composite measure demonstrated acceptable internal consistency (Cronbach's α = 0.71).

Sports participation. Sports participation was assessed using a single item: "In your leisure time, how often do you engage in physical exercise (e.g., running, swimming, ball sports)?" Response options: 1 = "almost never", 2 = "once a month", 3 = "2–3 times a month", 4 = "1–2 times a week", 5 = "3 or more times a week". Higher scores reflect more frequent participation.

Covariates. Based on prior literature, we included as covariates: gender (0 = male, 1 = female), age (continuous).

2.3. Statistical analysis

Analyses were conducted using Mplus 8.3 and SPSS 26.0. Descriptive statistics and Pearson correlations were first calculated.

Latent Class Growth Analysis (LCGA). LCGA was employed to identify heterogeneous trajectories of depressive symptoms. As a specialized procedure for identifying distinct longitudinal trajectories (Nagin, 2005), LCGA assumes that individuals within the same latent class share identical growth parameters (intercept and slope) with zero within-class variance (Nagin, 2005). We sequentially fitted models specifying 1 to 5 latent classes. Model selection was guided by the following criteria (Nylund et al., 2007; Marshall et al., 2023): (a) information criteria—lower Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC (aBIC) indicate better parsimony; (b) Entropy > 0.7 indicates adequate classification precision; (c) Bootstrap Likelihood Ratio Test (BLRT) and Lo-Mendell-Rubin adjusted likelihood ratio test (LMR-LRT) with $p < 0.05$ indicate that a k -class model fits significantly better than the $k-1$ class model; (d) class proportions > 5% of the sample and theoretically meaningful trajectory shapes. After selecting the optimal model, each participant's most likely trajectory class membership was saved. Recent LCGA studies among Chinese university students have demonstrated the utility of this approach for identifying heterogeneous mental health trajectories.

Multinomial logistic regression. To examine the predictive effects of T1 social capital and sports participation on trajectory class membership, we conducted multinomial logistic regression with the Moderate-Risk & Stable group as the reference category. Models adjusted for gender, age, and T1 sleep duration. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Longitudinal mediation model. A three-wave mediation model was specified: T1 social capital (predictor) → T2 sports participation (mediator) → T3 depressive symptoms (outcome). The model controlled for T1 depressive symptoms, gender, age, and T1 sleep duration on both the mediator and outcome. Bias-corrected nonparametric

bootstrapping with 5,000 resamples was used to test indirect effects; a 95% CI not containing zero indicates statistical significance (Hayes, 2018).

3. Results

3.1. Sample characteristics and descriptive statistics

After controlling for age and gender, the partial correlation analysis revealed that depressive symptoms were significantly positively correlated across the three time points ($r = 0.334$ to 0.445 , all $p < 0.001$), indicating moderate longitudinal stability. Sports participation was largely negatively correlated with subsequent depressive symptoms: T1 sports participation was correlated with T2 depression ($r = -0.096$, $p < 0.001$) and T3 depression ($r = -0.058$, $p = 0.020$); T2 sports participation was correlated with T2 depression ($r = -0.104$, $p < 0.001$) and T3 depression ($r = -0.102$, $p < 0.001$). These findings suggest that higher levels of sports participation at earlier time points exert a modest but stable protective lagged effect on later mental health.

Notably, social capital showed consistently positive correlations with depressive symptoms across all waves ($r = 0.069$ to 0.172), mostly $p < 0.01$), indicating that higher social capital was associated with more severe depressive symptoms—a pattern contrary to the conventional view that social capital is protective, possibly reflecting a “social burden” effect of social capital in this sample. Furthermore, the associations between social capital and sports participation were mostly weakly negative (e.g., T1 social capital with T1 sports participation: $r = -0.060$, $p = 0.017$). Sports participation was positively correlated between T1 and T2 ($r = 0.266$, $p < 0.001$) but negatively correlated between T2 and T3 ($r = -0.115$, $p < 0.001$), suggesting that university students’ exercise behavior fluctuated or even reversed direction over the follow-up period, potentially influenced by academic stress, seasonal factors, or life events. These partial correlation patterns provide basic information for understanding the net associations among the variables.

3.2. Identification of depressive symptom trajectory groups

Table 1 presents fit indices for LCGA models specifying 1 to 5 latent classes. The 3-class model was selected as optimal based on: (a) substantially lower BIC and aBIC than the 2-class model ($\Delta BIC = 78.54$); (b) Entropy = 0.794 (> 0.7); (c) significant LMR-LRT ($p < 0.001$) and BLRT ($p < 0.001$) for the 3-class solution; (d) the 4- and 5-class models had non-significant LMR-LRT ($p > 0.05$) and contained classes with proportions $< 5\%$. Therefore, the 3-class solution was retained.

Table 1
Fit indices for latent class growth models (N = 1,622).

Categories	BIC	Entropy	LMR-LRT p	BLRT p	Average latent class probabilities	Class size (n)				
						1	2	3	4	5
1	25622.54									
2	24918.99	0.791	< 0.001	< 0.001	0.85–0.96	309	1313			
3	24840.45	0.794	< 0.001	< 0.001	0.78–0.89	1107	82	433		
4	24817.40	0.690	= 0.062	< 0.001	0.65–0.88	293	87	137	1105	
5	24804.68	0.707	= 0.367	< 0.001	0.67–0.87	201	75	1055	272	19
Note: Bold indicates the selected 3-class model. BIC = Bayesian Information Criterion; LMR-LRT = Lo-Mendell-Rubin adjusted likelihood ratio test; BLRT = bootstrap likelihood ratio test.										

The three trajectories were characterized as follows (see Fig. 1): Class 1: "Low-Risk & Decreasing" (LRD; n = 1107, 68.3%). This class had the lowest initial depression level (intercept = 11.18) and showed a non-significant slight decreasing trend (slope = -0.18, p = .079), representing a psychologically healthy and stable group. Class 2: "High-Risk & Stable" (HRS; n = 82, 5.1%). This class had the highest initial depression level (intercept = 17.57) and showed a significant increasing trend (slope = 1.20, p = .010), representing a small but severely affected and potentially worsening group. Class 3: "Moderate-Risk & Stable" (MRS; n = 433, 26.7%). This class had a moderate initial depression level (intercept = 13.77) and showed a significant increasing trend (slope = 0.81, p < .001), representing a substantial group with subclinical but increasing symptoms(see Table 2).

Table 2
Parameter estimates for the three latent trajectory classes.

latent class	parameter	Estimate	SE	t	p
1	intercept	11.18	0.12	96.56	< 0.001
	slope	0.18	0.11	1.76	= 0.079
2	intercept	17.57	0.64	27.68	< 0.001
	slope	1.20	0.46	2.59	= 0.010
3	intercept	13.77	0.41	33.47	< 0.001
	slope	0.81	0.19	4.22	< 0.001
Note: SE = standard error.					

3.3. Predictive effects of social capital and sports participation on trajectory class membership

Using the “Moderate-Risk & Stable” (MRS) group as the reference, a multinomial logistic regression analysis was conducted to examine the predictors of the “Low-Risk & Decreasing” (LRD) and “High-Risk & Stable” (HRS) groups (see Table 3). Sports participation showed a significant positive predictive effect ($B = 0.041$, $p = 0.050$, $OR = 1.042$, 95% CI: 1.000–1.086), indicating that each unit increase in sports participation was associated with a 4.2% higher odds of being classified into the LRD group. Social capital exhibited a significant negative effect ($B = -0.198$, $p < 0.001$, $OR = 0.820$, 95% CI: 0.736–0.915), meaning that each unit increase in social capital was associated with an 18.0% lower odds of belonging to the LRD group. Age also had a significant negative influence ($B = -0.093$, $p = 0.001$, $OR = 0.911$, 95% CI: 0.862–0.964); each one-year increase in age reduced the odds of being in the LRD group by 8.9%. Gender was not significant ($p = 0.707$). In the comparison between the HRS and MRS groups, sports participation ($B = -0.055$, $p = 0.249$, $OR = 0.947$), social capital ($B = 0.078$, $p = 0.174$, $OR = 1.081$), and gender ($p = 0.982$) did not reach statistical significance. Age showed a marginally significant negative effect ($B = -0.100$, $p = 0.093$, $OR = 0.905$, 95% CI: 0.805–1.017), suggesting a trend that each one-year increase in age was associated with an approximately 9.5% lower odds of being classified into the HRS group.

In summary, sports participation, social capital, and age measured at T1 primarily helped distinguish the LRD from the MRS group, whereas none of the examined predictors significantly differentiated the HRS from the MRS group. Notably, age showed a negative trend in both comparisons, indicating that older university students were more likely to belong to the MRS group rather than the LRD or HRS groups. This finding may reflect complex associations between age and academic stage, life stress, or social role transitions. Future research should incorporate additional potential variables (e.g., psychological resilience, quality of social support, adverse childhood experiences) to improve the identification of individuals in the HRS group and to further explore the mechanisms underlying the age effect..

Table 3
Multinomial logistic regression predicting trajectory class membership (reference: Moderate-Risk & Stable group).

Predictor (T1)	LRD vs. MRS		HRSvs. MRS	
	B(SE)	OR	B(SE)	OR
Age	-0.09(0.03)	0.91 ^{***}	-0.10(0.06)	0.91
Social Capital	-0.20(0.06)	0.82 ^{***}	0.08(0.06)	1.08
Sports Participation	0.04(0.02)	1.04 [*]	-0.06(0.05)	0.95
Sex (Ref: Male)	-0.04(0.12)	0.96	-0.01(0.24)	1.00
Sex (Ref: Female)	0		0	
Note: T1 = baseline (2016). SE = standard error; OR = odds ratio; [*] $p < 0.05$, ^{***} $p < 0.001$.				

3.4. Longitudinal mediation by sports participation

We constructed a three-wave mediation model (Fig. 2) to test whether sports participation mediated the association between social capital and later depressive symptoms. The model controlled for T1 depressive symptoms, gender, age, and T1 sleep duration. All path coefficients are standardized.

Direct path from T1 social capital to T3 depressive symptoms: $\beta = 0.23$ ($p < 0.05$). Path from T1 social capital to T2 sports participation: $\beta = -0.22$ ($p < 0.05$). Path from T2 sports participation to T3 depressive symptoms (controlling for T1 depression): $\beta = -0.13$ ($p < 0.05$).

The indirect effect via T2 sports participation was 0.03 (95% bias-corrected CI [0.01, 0.05]), which did not contain zero, confirming statistical significance. Thus, higher social capital was associated with slightly lower sports participation, which in turn was associated with slightly higher subsequent depressive symptoms, representing a partial but significant mediating pathway.

4. Discussion

This study employed latent variable mixture growth modeling to identify the developmental trajectories of depressive symptoms among college students, and further examined the predictive roles of gender, age, social capital, and physical activity participation in trajectory class membership, as well as the mediating role of physical activity participation.

4.1 Subgroups of Depressive Symptom Trajectories in College Students

The present study identified three heterogeneous trajectories of depressive symptoms among college students: a low-risk declining group (LRD, 68.3%), a moderate-risk stable group (MRS, 26.7%), and a high-risk rising group (HRS, 5.1%). Among these, the LRD group exhibited a positive pattern characterized by a low initial level followed by sustained remission, and this subgroup accounted for the largest proportion of the sample. This finding is consistent with previous research, which has consistently shown that the majority of college students maintain relatively low levels of depression (Liang et al., 2022; Bulhões C et al., 2020). The MRS group was characterized by a moderate starting point with gradual deterioration, suggesting that this subgroup faces latent depressive risk, underscoring the need for early identification and preventive interventions among these students. The HRS group demonstrated a high initial level with rapid escalation, indicating that this subgroup is at high risk for depression and urgently requires targeted psychological interventions.

4.2 The "Dark Side" of Social Capital: Theoretical Explanations and Mechanistic Analysis

Partial correlation analyses and multinomial logistic regression in this study consistently revealed that social capital was significantly and positively associated with depressive symptoms after controlling for age and gender, and higher social capital was associated with lower odds of belonging to the low-risk group relative to the moderate-risk group. This finding contradicts the protective role traditionally emphasized in social capital theory (Coleman, 1988; Knote, 2004), which underscores the salutary effects of social capital on individual development through mechanisms of trust, norms, and information channels. Although the majority of the literature continues to emphasize the protective effects of social capital on mental health, with studies demonstrating that high levels of structural and cognitive social capital significantly reduce the risk of depression (Mao & Chen, 2021; Yang et al., 2025), these conclusions are predominantly derived from studies of adult and older adult populations, and their generalizability to college student populations is subject to certain limitations. Indeed, a systematic review by Kemppainen and Timonen explicitly noted that findings regarding the relationships between different dimensions of social capital, structural versus cognitive, and bonding versus bridging, and depression remain

mixed(Kemppainen & Timonen,2024), suggesting that the mental health effects of social capital are highly contingent upon the measurement dimensions employed and the study context.

In recent years, a growing body of research has drawn attention to the "dark side of social capital"—that is, its potential to produce unanticipated health-harming effects in specific populations. A study based on a probability sample of urban residents in China found that although total social capital, bonding capital, and bridging capital were each negatively associated with depressive symptoms, "negative social capital" was positively associated with depression. This finding directly supports the existence of harmful components within social capital (Chen et al., 2018). Notably, another study reported that individual-level relational burden stemming from both kin and non-kin ties was significantly associated with higher levels of depression and loneliness (Kim et al., 2022). The positive association between social capital and depression captured in this study aligns closely with the above theoretical framework of social capital as a "mixed blessing" and can be interpreted through two interrelated mechanisms: the "crowding-out" mechanism and the "social burden" mechanism.

First, the crowding-out mechanism. Bourdieu's theory of social capital posits that social capital is not an independent abstract resource but is embedded in power-relation networks across different fields, with its effects contingent upon the structural characteristics of the field(Bourdieu,1986). The social capital measure in this study (T1) was collected in 2016, corresponding to the early stage of college enrollment. At this stage, higher levels of social capital typically entail intensive peer interaction, which requires substantial investments of time, emotion, and energy. Using ordered logistic regression analyses of data from the 2023 China General Social Survey (CGSS), Liu et al. found that each additional hour of working time significantly reduced residents' sports participation across all regions. This finding clearly reveals the universal role of "time constraints" in health behaviors—a mechanism that is particularly salient among college students(Liu et al., 2026): the denser the social network, the lower the proportion of an individual's "available time budget" allocated to physical activity, thereby producing a time-based "crowding-out effect" on health behaviors.

Second, the social burden mechanism. In specific sociocultural contexts, high social capital also entails denser obligation networks and reciprocity expectations. Coleman argued that social capital operates through three pathways: "obligations and expectations," "information channels," and "social norms."(Coleman,1988) Among college students, "social norms" may be concretized into peer pressures such as "must fit in" and "cannot refuse." Individuals are thus required to frequently respond to peer requests and navigate intra-group evaluation and comparison processes. A study demonstrated that parental expectations significantly and positively influenced psychological distress through a chain-mediated pathway involving perceived stress and devaluation of core self-worth; notably, perceived stress alone accounted for 27.3% of the indirect effect, highlighting its central mediating role in the relationship between school-environmental pressures and mental health(Zhou et al., 2025). For college students, high social capital embeds individuals in denser social networks, thereby exposing them more frequently to social evaluation and comparison, which in turn activates a chronic social stress response centered on perceived stress. Sustained social stress can activate the hypothalamic-pituitary-adrenal (HPA) axis, leading to abnormally elevated cortisol levels, which subsequently impair brain emotion-regulation circuits through accumulated allostatic load, ultimately manifesting as elevated depressive symptoms. The positive association between social capital and depression observed in this study may, in this sense, reflect the emotional and psychological costs of social capital during this specific developmental stage of Chinese college students. This interpretation is also consistent with recent empirical findings on the "dark side" of social capital.

A noteworthy cultural dimension is that the social capital measure used in this study may implicitly reflect the dominance of "strong ties" in the Chinese context. Under the "differential mode of association" social structure identified by Fei Xiaotong, individuals' social capital is predominantly based on strong ties grounded in kinship, geographic proximity, and peer relationships. Although strong-tie networks provide robust emotional support, they also entail higher obligation density and risk of emotional contagion. By contrast, "weak ties" characterized by information sharing and instrumental reciprocity, with their lower emotional involvement and lighter social burden, may be more conducive to the mental health of young people. The composite social capital score employed in this study did not differentiate between "bonding" and "bridging" types of capital, which may represent an important methodological reason why the net effect of social capital emerged as a positive association.

4.3 The Protective Role of Sports participation: Mediating Pathways and Boundary Conditions

Partial correlation analyses and multinomial logistic regression in this study clearly confirmed the protective effect of physical activity on the mental health of college students: physical activity at both T1 and T2 was significantly negatively correlated with subsequent depressive symptoms, and each unit increase in physical activity was associated with a 4.2% higher odds of belonging to the low-risk group. This finding is highly consistent with evidence from recent systematic reviews and longitudinal studies (Hou et al., 2025; Alexandra Martín et al., 2026). These studies have demonstrated that physical activity and depressive symptoms are bidirectionally related, such that depressive symptoms also negatively predict subsequent physical activity levels, revealing a dynamic reciprocal relationship between physical activity and mental health. A consistent association has been established between higher levels of physical activity participation and lower levels of depression, anxiety, and stress.

However, physical activity in this study failed to significantly distinguish the high-risk rising group from the moderate-risk stable group, suggesting that for college students already in a state of severe depression, physical activity alone may be insufficient to fully reverse their deteriorating trajectory. This result is also consistent with the bidirectional causality findings noted above, in that individuals in the high-risk group may generally exhibit lower levels of physical activity due to the severity of depressive symptoms and motivational deficits, thereby creating a vicious cycle in which worsening depression leads to reduced exercise, which in turn further exacerbates depression.

The mediation analysis in this study revealed an unexpected but theoretically illuminating indirect pathway, namely that social capital influences depressive symptoms through physical activity, with an indirect effect of 0.03. Although the effect size is modest, this finding carries important theoretical implications, as it reveals that physical activity not only exerts a direct protective effect on depression but also functions as a mediating pathway through which social capital is transmitted to mental health outcomes. Specifically, higher levels of social capital at T1 predicted lower levels of physical activity at T2, which in turn predicted higher levels of depressive symptoms at T3. At the practical level, this result suggests that interventions for college students with high social capital should focus not simply on increasing social capital or expanding social networks, but rather on the transfer and rebalancing of health behaviors. Specifically, by migrating some social activities to exercise settings such as sports clubs, running groups, or other outdoor activities with lower social pressure, students with high social density can be guided toward a balanced time allocation model that harmonizes social engagement and physical activity.

4.4 Limitations and Future Directions

Several methodological limitations of this study warrant acknowledgment. First, social capital was measured using a unidimensional composite indicator that did not differentiate between structural versus cognitive or bonding versus bridging dimensions of social capital. Future research should adopt multidimensional social capital instruments to more finely characterize the differential directional effects of distinct social capital types on health behaviors. Second, the measurement of Sports participation focused primarily on frequency and did not adequately capture dimensions such as activity type, intensity, motivation, or social context. Third, although this study employed a three-wave longitudinal design, causal inference remains constrained by the inherent limitations of observational research, making it difficult to fully eliminate self-selection bias and unmeasured confounding. Fourth, the sample was drawn from colleges in specific regions of China, and the external validity of the findings awaits replication across regional and cross-cultural samples.

In terms of practical implications, the findings of this study provide actionable guidance for mental health promotion in higher education settings. In designing mental health education and physical education curricula, universities should guide students to shift from an "expansion of social capital quantity" approach toward "structural optimization of social capital and rebalancing of time allocation," with appropriate relative proportions of social interaction time and Sports participation time. Sports clubs and outdoor physical activities should be recognized as having a unique role as "social-exercise compound settings," enabling even socially active students to participate in physical exercise with a lower psychological threshold. Crucially, for students in the high-risk rising group (approximately 5%), a multi-dimensional intervention system integrating psychological resilience training, exercise prescriptions, and social support enhancement should be established to halt the progressive deterioration of depressive symptoms.

5. Conclusion

This study integrated latent class growth modeling with longitudinal mediation analysis using three-wave data from Chinese college students, revealing three heterogeneous developmental trajectories of depressive symptoms and the indirect pathway through which social capital influences depression via Sports participation. Results showed that social capital was positively associated with depressive symptoms, with higher social capital associated with lower odds of belonging to the low-risk group; Sports participation exerted a stable but modest protective effect; and the indirect pathway (social capital→sports participation→depressive symptoms) along with the counterintuitive effect of social capital points to the importance of attending to the "crowding-out" and "social burden" mechanisms of social capital in mental health interventions. Age showed a negative effect in both group comparisons, indicating that older college students were more likely to belong to the moderate-risk group. Future research should incorporate differentiated multidimensional social capital measures, detailed assessment of exercise type and intensity, and cross-regional sample replication to enhance external validity and intervention precision.

Declarations

Abbreviations

NA

Ethics approval and consent to participate

This study is a secondary analysis of de-identified data from the China Family Panel Studies (CFPS), which is a nationally representative survey conducted by the Institute of Social Science Survey, Peking University. The CFPS data collection protocol was approved by the Biomedical Ethics Review Committee of Peking University (approval number: IRB00001052-14010), and written informed consent was obtained from all participants at the time of the original survey. The present study used only anonymized, publicly available data and involved no direct contact with human subjects. Therefore, no additional ethical approval or informed consent was required for this secondary analysis

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the China Family Panel Studies (CFPS), which is conducted by the Institute of Social Science Survey (ISSS) at Peking University. The datasets are publicly available to qualified users upon application through the official CFPS website: <https://opendata.pku.edu.cn/dataverse/CFPS>.

Competing Interests

The authors declare that they have no competing interests.

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Authors' contributions

Li took charge of the conceptualization, data curation, formal analysis, methodology, visualization and writing-original draft.

Chen took charge of the supervision.

All authors read and approved the manuscript and all data were generated in-house and that no paper mill was used.

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Figures

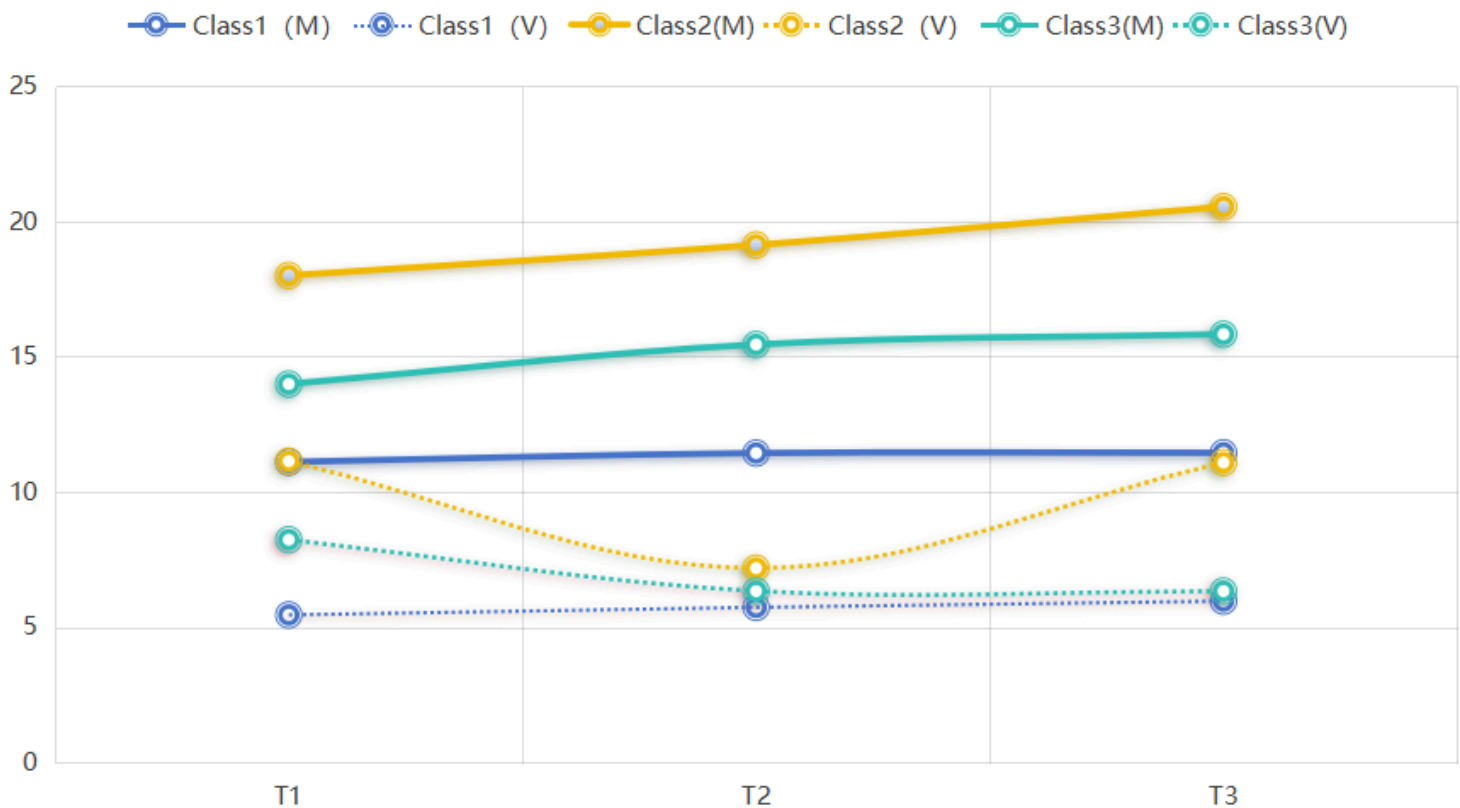


Figure 1

Trajectory plot of depressive symptoms from T1 (2016) to T3 (2020) for the three latent classes.

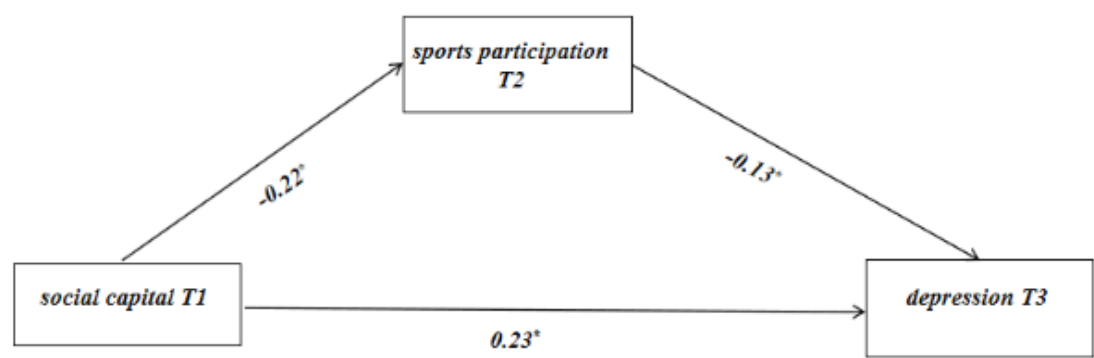


Figure 2

Longitudinal mediation model