scientific reports

Check for updates

OPEN

The relationship between interpersonal trust, family capital, and physical activity behavior among university students: a cross-lagged study

Bo Li[1], Ying He[2]✉ & Xielin Zhou[1]

To explore the interaction mechanism between interpersonal trust, family capital, and physical activity behavior among college students using a cross-lagged study design, providing a theoretical basis for the healthy development of their physical and mental well-being. A longitudinal follow-up survey was conducted among 412 college students in Sichuan Province, using the Interpersonal Trust Scale, Physical Activity Rating Scale, and Family Capital Scale, in two phases over eight weeks from early March (T1) to early May (T2) 2024. (1) The autoregressive path coefficients for interpersonal trust, family capital, and physical activity behavior were 0.51, 0.41, and 0.66, respectively, indicating good stability ($p < 0.001$). (2) Interpersonal trust at T1 positively predicted family capital at T2 ($\beta = 0.28$, $p < 0.001$), and family capital at T1 also positively predicted interpersonal trust at T2 ($\beta = 0.23$, $p < 0.001$), indicating a mutual influence between family capital and interpersonal trust. (3) Family capital at T1 did not predict physical activity behavior at T2 ($p > 0.05$), but physical activity behavior at T1 positively predicted family capital at T2 ($\beta = 0.20$, $p < 0.001$), indicating that physical activity behavior is a causal variable for family capital. (4) Interpersonal trust at T1 positively predicted physical activity behavior at T2 ($\beta = 0.16$, $p < 0.001$), while physical activity behavior at T1 did not predict interpersonal trust at T2 ($p > 0.05$), suggesting that interpersonal trust is a causal variable for physical activity behavior. (5) Family capital mediated the relationship between interpersonal trust and physical activity behavior ($\alpha = 0.046$), with a confidence interval of [0.014,0.097]. There were no gender differences in the relationship between interpersonal trust, family capital, and physical activity behavior among college students. There was a longitudinal relationship between interpersonal trust, family capital, and physical activity behavior, where family capital and interpersonal trust mutually influence each other. Physical activity behavior was a positive causal variable for family capital, while interpersonal trust was a positive causal variable for physical activity behavior. Additionally, family capital mediated the relationship between interpersonal trust and physical activity behavior.

The term "physical activity behavior" describes a range of structured and intentional physical activities performed by an individual to improve physical fitness, enhance athletic performance, and similar objectives[1,2]. Numerous prior studies have established that consistent engagement in physical activity can markedly improve both physical and mental well-being[3–6], regular physical activity is associated with the prevention of chronic conditions, including cardiovascular disease and diabetes, while also contributing to improved mood and a reduction in depression and anxiety[7–9]. Despite the widespread acknowledgment of the advantages associated with physical activity, many adults worldwide continue to fail to meet the recommended levels of engagement in such activities. The Global Status Report on Physical Activity 2022, released by the World Health Organization (WHO), indicates that around 1.4 billion adults globally, representing 27.5% of the adult population, fail to adhere to the recommended guidelines of engaging in a minimum of 150–300 min of moderate-intensity or 75–150 min of vigorous-intensity physical activity each week. In China, the issue is similarly grave. Studies indicate that inadequate physical activity is widespread among the youth population, with a notable decline in physical fitness levels, particularly among college students[10]. Lack of physical activity has become a significant

[1]Department of Sports Training, Chengdu Sport University, Chengdu 610041, Sichuan, China. [2]Teaching Quality Evaluation Center, Chengdu Sport University, Chengdu 610041, Sichuan, China. ✉email: quinlan957@163.com

risk factor for health[11,12]. A survey conducted in 2023, which included 25,125 college students from across the nation, indicated that nearly 50% of them do not engage in physical activity at a frequency of three times per week or more[13]. Moreover, the 2022 Survey Report on the Mental Health Status of Chinese College Students indicates that 21.48% of students are at risk of depression, while 45.28% are at risk for anxiety disorders[14]. These data further highlight the severity of the current physical and mental problems of college students. Therefore, the improvement of physical activity behavior of college students has become a public health challenge that needs to be solved urgently.

Researchers have demonstrated that variables such as social exclusion, social anxiety, peer relationships, and social support significantly influence an individual's engagement in physical activity[15,16]. These elements are often intricately linked to the individual's degree of interpersonal trust. For instance, research indicates that the rapid pace of modernization and heightened social mobility have contributed to a decrease in the overall level of interpersonal trust among adolescents[17]. This decline in trust has implications for their engagement in various social practices, including physical activities[18]. Furthermore, the efficacy of interpersonal skills has a significant impact on adolescents' perceptions of social inferiority and their mental health, which subsequently influences their engagement in physical activity[19]. Relevant studies have further indicated that the deterioration of physical fitness among youth cannot be attributed solely to the educational system; rather, it is a multifaceted issue that encompasses the roles of educational institutions, familial influences, and societal factors within a particular historical framework[20,21]. The social interpersonal relationships of university students predominantly revolve around academic interactions. However, during holiday periods, students return to their familial environments, which subsequently become the primary context for their academic experiences. This familial setting significantly influences the development of their perceptions of exercise and the cultivation of their physical activity behaviors. Research has indicated that family economic and cultural capital play a significant and beneficial role in facilitating and encouraging physical activity (PA) among adolescents[22]. And evidence available suggests that higher levels of family social capital are associated with greater physical activity[23]. While an emerging literature supports the interrelationships among family capital, interpersonal trust and physical activity behavior[24,25], longitudinal evidence on whether changes in family capital and interpersonal trust are associated with changes in physical activity behavior is still scarce. Therefore, the objective of this study is to explore the relationships among interpersonal trust, family capital, and physical activity behavior to enhance the physical and mental well-being of university students.

Literature review

Family capital and physical activity behavior

Family capital refers to the inherent predispositions of individuals that cannot be altered through personal effort. It includes the family's allocation of resources and emphasizes the role of familial background in individual development[26]. Family capital has three dimensions: cultural, social, and economic. Cultural capital reflects genetic influences, economic capital pertains to the family's investment capacity, and social capital represents political resources and social standing[27]. The family serves as the foundational context for the education of adolescents and plays a crucial role in the development of healthy lifestyle habits. Ecosystem theory suggests that multilevel environmental factors (e.g., family factors) can directly or indirectly influence individual's physical activity levels[28]. Furthermore, family capital, as a significant component of the family system, is frequently associated with the health behaviors of adolescents[29]. Research indicates that households in urban communities have relatively high levels of social capital, expenditure consumption and individual education levels compared to rural areas, and also exhibit higher levels of physical activity behavior[30]. Higher-income families enhance their children's engagement in sports by augmenting their resources, which subsequently leads to a rise in their children's participation in athletic activities[31,32]. In addition, the cultural capital of a family plays a significant role in shaping an individual's exercise habits[33]. Therefore, this study proposes hypothesis 1a: Family capital can positively predict physical activity behavior.

On the other hand, the physical activity behavior is conducive to the formation of harmonious relationships among family members, thereby contributing to the accumulation of family capital. The evidence from research studies indicates that engaging in physical activity can contribute to strengthen the bonds between family members. The incorporation of physical activity within the familial environment, such as family fitness and group exercise, has been demonstrated to foster robust emotional bonds between individuals and their parents. Such activities not only facilitate improvements in the health of family members, but also provide an optimal environment for interaction and communication among family members[34]. Physical activity in the domestic context (e.g., family fitness activities) contributes to the harmonious development of the family. Furthermore, physical activity within the home context, including family fitness initiatives, supports the harmonious development of the family unit, enhances familial intimacy, and refines parenting styles[35]. In other words, physical activity is an effective method of improving the relationships among family members, enhancing the functioning of the family, and building up the family's capital. Therefore, this study proposes hypothesis 1b: physical activity behavior positively predicts family capital.

Interpersonal trust and physical activity behavior

Interpersonal trust can be described as the belief an individual holds regarding the dependability of another person's statements and commitments[36], which is mutually acknowledged by both parties without apprehension of betrayal[37]. Interpersonal trust among college students is positively correlated with various factors, including social support, peer relationships, and personality traits, all of which can influence fundamental psychological well-being[38]. According to the theory of social support, both instrumental and emotional support serve as the foundation for human beings' healthy activities[39]. In other words, when individuals possess sensitivity to the surrounding environment and perceive that they are provided with sufficient trust and support by the environment

in which they are situated, they are able to maintain healthy activities. Further research has confirmed that an increased perception of emotional support facilitates the mobilization of an individual's positive psychological resources, thereby enhancing the persistence of physical activity and fostering healthy behaviors[40]. In contexts related to physical activity, elements of interpersonal trust—such as friendship, acceptance, and support among peers—often play a more critical role in sustaining exercise than various objective environmental factors[41]. Such interpersonal interactions foster a collective influence that creates an exercise-oriented atmosphere, enhancing emotional experiences and motivating individuals to establish a consistent exercise habit[42]. Therefore, this study proposes Hypothesis 2a: Interpersonal trust positively predicts physical activity behavior.

Established theories and existing literature indicate that physical activity serves as one of the most efficacious interventions for individuals seeking to cultivate positive psychological attributes and foster balanced physical and psychological growth. Empirical research has substantiated that engagement in physical activity facilitates the development of interpersonal skills, acceptance, and peer relationships[43]. In general, adolescents who engage in regular physical activity exhibit enhanced communication abilities, greater enjoyment in social interactions, and the capacity to establish supportive interpersonal networks, as well as to cultivate interpersonal trust[44]. Furthermore, individuals who participate in physical activity on a frequent basis demonstrate higher levels of sustained trust and pro-social behaviors compared to those who engage in physical activity infrequently[45]. This perspective is further supported by the social capital theory of sport, which emphasizes that physical activity behavior serves as a significant medium for intergroup communication, offering a distinctive context and a unique group experience conducive to the reformation of interpersonal trust. Within the realm of sports, the dynamics of teamwork and shared objectives foster an environment conducive to trust, allowing individuals to momentarily diminish their self-awareness and progressively assimilate into the collective milieu. This process facilitates the development of positive interactions and interpersonal trust among participants[46]. Consequently, this study posits Hypothesis 2b: Physical activity behavior positively predicts interpersonal trust.

Interpersonal trust and family capital

The family serves as a crucial social stabilizer and represents the primary environment for individual growth and development. Research indicates a significant positive correlation between family capital and family size, suggesting that an increase in family capital is associated with a larger family size[47]. Furthermore, family size is intricately connected to risk factors. According to family life cycle theory, individuals' propensity for risky investment behavior is influenced by variations in family structure, including aspects such as family size and demographic characteristics[48]. Trust, regarded as an individual characteristic, represents a psychological state manifested by individuals when engaging in risk-taking behaviors[49]. The Trust Integration Model posits that interpersonal trust constitutes a decision or action undertaken in the context of perceived risk[50]. The research highlights that risk emerges as a pivotal factor in the development of interpersonal trust, particularly in settings devoid of oversight and third-party enforcement mechanisms, where any act of trust inherently involves an element of risk[51]. Consequently, interpersonal trust can be conceptualized as a precarious investment, as individuals must contend with the potential for betrayal in their interactions with others[52]. In summary, the preceding analysis indicates that family size influences individual engagement in risky investment behaviors. Furthermore, there exists a positive correlation between family size and family capital. Additionally, interpersonal trust, which is considered a form of risky investment behavior, may also be associated with family capital to some degree. Accordingly, this study proposes Hypothesis 3a: Family capital positively predicts interpersonal trust.

The formation of interpersonal trust represents the foundational and most primitive form of trust formation, serving as the bond that maintains interconnection between people. According to social support theory, the diverse forms of supportive resources that individuals obtain from family, friends, and other members of their interpersonal interaction networks play a crucial role in promoting both physical and mental well-being[53]. Numerous studies have identified a notable correlation between interpersonal trust and social support[54]. Integrating these findings with social support theory suggests that individuals who perceive care and support from others are more likely to develop trust in those individuals, thereby fostering closer interpersonal relationships. Family support constitutes a critical component of social support; an increase in familial support correlates with heightened intimacy among family members. Empirical research indicates that familial closeness can substantially enhance family capital, thus offering robust support for the growth and development of its members[55]. It can be inferred that the positive influence of interpersonal trust among college students on family capital may occur through an indirect mechanism. More specifically, elevated levels of interpersonal trust are likely to strengthen family support, which subsequently fosters family intimacy and ultimately contributes to the enhancement of family capital. Consequently, this study posits Hypothesis 3b: Interpersonal trust serves as a positive predictor of family capital.

Ultimately, the preceding analysis of the relationship between physical activity behavior and family capital, as well as family capital and interpersonal trust, reveals that family capital may exert a stabilizing influence on the relationship between interpersonal trust and physical activity behavior. In light of the preceding hypotheses, this study proposes Hypothesis 4: Family capital functions as a mediating variable between physical activity behavior and interpersonal trust.

In conclusion, numerous previous studies have substantiated the interrelationship between interpersonal trust, family capital, and physical activity behavior. However, conclusions about the relationship between these three variables are inconsistent, and most studies are cross-sectional, limiting their reliability. This study uses a longitudinal tracking survey and cross-lagged analysis to investigate the relationships among these variables among college students and the mechanisms involved. The aim is to develop a structural equation model (see Fig. 1) by selecting the best model from competing options and examining causal associations. This research seeks to provide new insights into college students' health behaviors, offering valuable references for related research and practice.

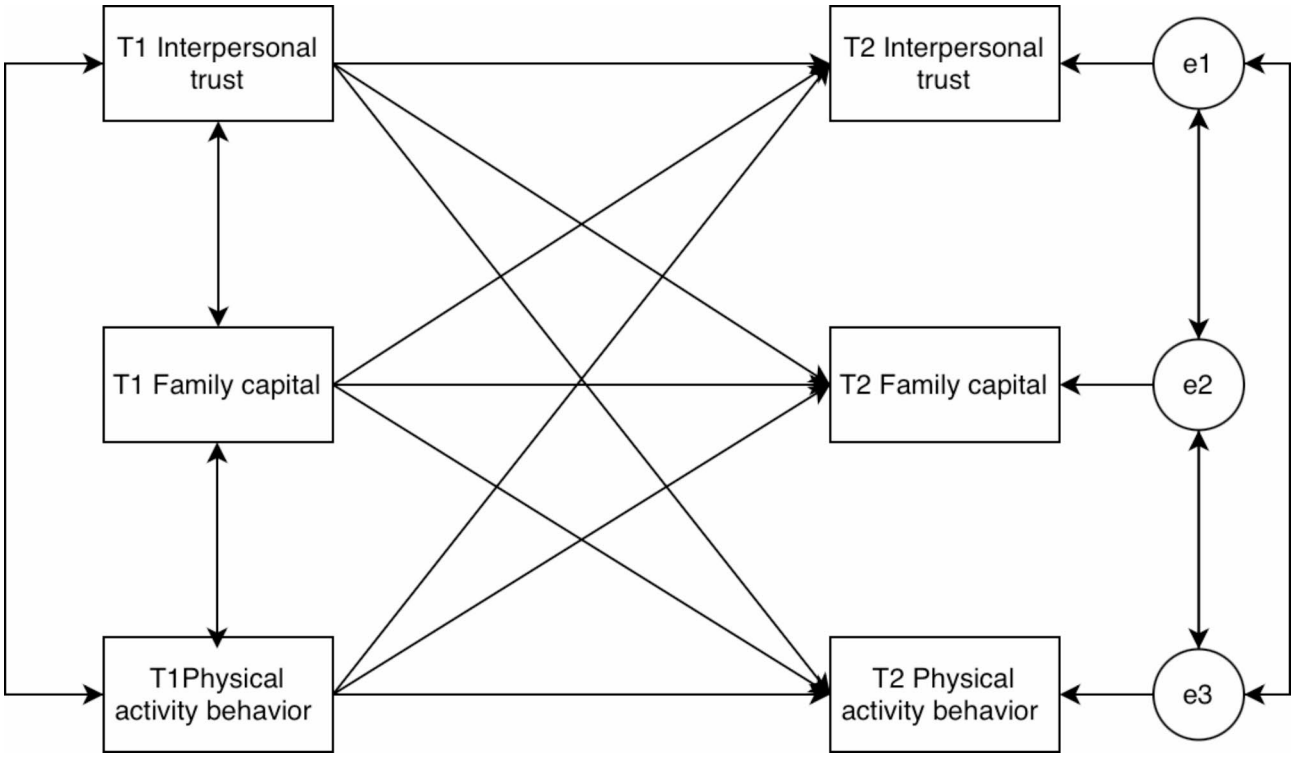

Fig. 1. Model of conceptual framework.

Methods

Participants

In this study, the principle of convenience sampling was employed, and the students from three universities in Sichuan Province were selected as the target participants. Additionally, since the physical activity behavior of college students tends to be centralized during their academic years, a longitudinal study was conducted in the first semester of 2024 over an eight-week period, divided into two phases. The initial survey (T1) was conducted at the beginning of March 2024. A total of 458 questionnaires were distributed, and 442 responses were collected. After screening for the "judgment of regularity of filling in the answers" and "missing information," 431 pieces of valid data were retained. The second survey (T2) was conducted in May 2024, employing the same screening principles as T1. A total of 424 copies were retained. The 412 valid data points from all completed surveys were used as the final sample for analysis. Out of the total number of respondents, 242 were male and 170 were female. Study consent was obtained from the school leader, the head teacher and the subject himself before testing. The questionnaire follows the principles of voluntary filling, anonymous filling and data confidentiality. This study was approved by the Ethics Committee of Chengdu Sport University, and adhered to the principles of the Declaration of Helsinki. All participants signed an informed consent form before the survey.

Measures

Interpersonal trust scale (ITS)

The study utilized the Chinese version of the Interpersonal Trust Scale, originally developed by Rotter[56] (1967). This scale consists of 25 questions and is designed to measure both general and specific trust. Responses are rated on a five-point Likert scale, where a score of one signifies total disagreement, and a score of five signifies complete agreement. A higher total score indicates a greater level of trust in interpersonal relationships. In this study, the reliability of the scale was assessed at two different time points, T1 and T2. The results demonstrated high stability and reliability, with Cronbach's α coefficients of 0.936 and 0.938 for T1 and T2, respectively, indicating consistent measurements of interpersonal trust.

Family capital scale (FCS)

The Family Capital Scale, developed by Wang Lei[57] (2018), was utilized, exhibiting a Cronbach α coefficient of 0.835, indicative of high validity and reliability. The scale is divided into three dimensions: family economic capital, family social capital, and family cultural capital. A total of 10 questions are included, using a 5-point Likert scale, to quantitatively assess the level of family capital. In particular, a higher score on the scale indicates a higher level of family capital. The FCS has good reliability and validity, with a Cronbach's alpha coefficient of 0.872 in T1 and 0.909 in T2. The coefficients exceeded 0.8, indicating that the scale has high stability and reliability in this study and can effectively assess the level of household capital.

	M ± SD	X1	X2	Y1	Y2	Z1	Z2
T1 Interpersonal trust	3.08 ± 0.63	1					
T2 Interpersonal trust	3.18 ± 0.64	0.669**	1				
T1 Family capital	3.08 ± 0.66	0.701**	0.586**	1			
T2 Family capital	3.10 ± 0.70	0.614**	0.498**	0.674**	1		
T1 Physical activity behavior	3.09 ± 0.63	0.518**	0.493**	0.543**	0.537**	1	
T2 Physical activity behavior	3.10 ± 0.61	0.511**	0.455**	0.476**	0.591**	0.748**	1

Table 1. Correlation analysis of the relationship between family capital, interpersonal trust and physical activity behavior among university students. "*"represents $p<0.05$, "**" represents $p<0.01$.

Physical activity behavior scale (PABS)

The Physical Activity Rating Scale, developed by Liang Deqing et al.[58] (1994), was selected for its proven effectiveness in measuring college students' exercise behavior. This scale has been widely used by scholars in China and has been validated for use in this context. The scale encompasses three dimensions. To ensure the operationalization and accuracy of the study, some of the questions in each dimension were deleted in equal proportions, with 30 questions ultimately being used as the basis for the assessment. the Cronbach's α values of the two tests were 0.949 and 0.942, respectively.

Data processing

In this study, the collected data were processed and analyzed using SPSS 27.0 and AMOS 26.0[1]. The common method bias test, descriptive statistics, correlation analysis, independent samples t-test, and analysis of variance (ANOVA) were performed through SPSS. AMOS was utilized for the construction of the model and the examination of the relationship between the variables.

Ethics statement

All methods were carried out according to relevant guidelines and regulations. The studies involving human participants were reviewed and approved by Chengdu Sport University ethics committee (Ethical Approval Number: 202468). The participants provided their written informed consent to participate in this study.

Results

Common method bias test

The common method bias was tested using the Harman's one-way test[59]. A total of 15 factors with eigenroots greater than 1 were extracted from the results of the initial time point (T1). Among the extracted factors, the first factor cumulatively explained 32.01% of the total variance, which was less than the critical criterion of 40%. The results of the second time point (T2) extracted a total of 15 factors with characteristic roots greater than 1. Among them, the first factor cumulatively explained 30.34% of the total variance, which was also less than the critical criterion of 40%. This indicated that there was no serious common method bias in both the first and the second measurements of this study.

Descriptive statistics and correlation analysis of interpersonal trust, family capital and physical activity behavior among college students

The descriptive statistics results (Table 1) indicate that the interpersonal trust, family capital, and physical activity behavior of T1 and T2 were above 3, which is greater than the middle value (3) on a 5-point scale. The correlation analysis (Table 1) revealed that T1 interpersonal trust and T1 family capital ($r=0.701$) exhibited a positive and significant correlation ($p<0.001$), as did T1 and T2 physical activity behavior ($r=0.748$) and T1 and T2 family capital ($r=0.674$). The preceding data demonstrate that the interpersonal trust, family capital, and physical activity behavior of college students exhibit synchronous correlation and stability over time during the 8-week period.

T-test and ANOVA on interpersonal trust, family capital, and physical activity behavior among college students

In this study, independent samples t-tests were conducted at two time points to assess the impact of gender and household location on the subjects (as shown in Table 2). With regard to gender, the results of the Levine's variance equivalence test indicated a significant difference in T1 family capital ($p=0.024$). Consequently, equal variance data were employed without assuming equal variance. In the t-test of equivalence of means, no significant difference ($P>0.05$) was observed between the two measures of interpersonal trust, family capital, and physical activity behavior by gender. Conversely, in the Levin's variance equivalence test for household location, all variables were found to be non-significant ($P>0.05$) at both time points. Consequently, the assumption of equal variance was employed. A further analysis was conducted using an ANOVA to compare the age and academic level of the variables measured (as shown in Table 3). This revealed that there was no significant difference between the two time points in terms of academic level and age ($p>0.05$).

[1]For detailed information, please refer to Supplementary Material 1.

Cluster variables	Dependent variable	HV-test	Levine's test of variance equivalence		Mean equivalence t-test	
			F	P	t	P
Gender	T1 Interpersonal trust	Assuming equal variance	1.525	0.218	-0.221	0.825
	T2 Interpersonal trust	Assuming equal variance	0.177	0.674	0.013	0.989
	T1 Family capital	Assuming unequal variance	5.103	0.024*	0.118	0.908
	T2 Family capital	Assuming equal variance	1.397	0.238	-0.665	0.507
	T1 Physical activity behavior	Assuming equal variance	0.165	0.685	-0.994	0.321
	T2 Physical activity behavior	Assuming equal variance	0.016	0.899	-0.925	0.356
Household location	T1 Interpersonal trust	Assuming equal variance	2.547	0.111	0.4	0.689
	T2 Interpersonal trust	Assuming equal variance	2.83	0.093	-0.599	0.55
	T1 Family capital	Assuming equal variance	0.563	0.454	-0.185	0.854
	T2 Family capital	Assuming equal variance	0.414	0.52	-0.73	0.466
	T1 Physical activity behavior	Assuming equal variance	0.737	0.391	0.522	0.602
	T2 Physical activity behavior	Assuming equal variance	0.153	0.696	-0.489	0.625

Table 2. Independent samples t-test for gender and hukou location for T1 and T2. "*" represents $p<0.05$, "**" represents $p<0.01$.

Cluster variables	Dependent variable	Mean square	F	*P*
Grade	T1 Interpersonal trust	0.107	0.269	0.898
	T2 Interpersonal trust	0.355	0.865	0.485
	T1 Family capital	0.278	0.643	0.632
	T2 Family capital	0.37	0.755	0.555
	T1 Physical activity behavior	0.375	0.939	0.441
	T2 Physical activity behavior	0.438	1.19	0.315
Age	T1 Interpersonal trust	0.14	0.353	0.842
	T2 Interpersonal trust	0.443	1.08	0.366
	T1 Family capital	0.37	0.858	0.489
	T2 Family capital	0.236	0.48	0.751
	T1 Physical activity behavior	0.352	0.882	0.474
	T2 Physical activity behavior	0.456	1.24	0.293

Table 3. ANOVA for grade and age for T1 and T2.

Cross-lagged analysis of family capital, interpersonal trust, and physical activity behavior among college students

AMOS 26.0 was employed to construct a model of college students' family capital, interpersonal trust, and physical activity behavior. First, the baseline model M1 was constructed (Fig. 2), and then the cross-lagged paths were added to construct models M2 to M8 (Figs. 2, 3, 4, 5, 6, 7, 8 and 9). The fit indicators for each model are presented in Table 4.

As illustrated in Table 4, the M8 model exhibited the most optimal metric fit among the competing models ($\chi^2/df = 3.424$, GFI = 0.989, CFI = 0.993, RMSEA = 0.077). Its performance was demonstrably superior to that of all previous models. This excellent performance is a consequence of the fine-tuning of the M7 model. Specifically, the M8 model was constructed by removing the insignificant path Y1→Z2 from the M7 model. Additionally, given that M7 is a saturated model, the path Z1→X2 was also removed. These modifications resulted in a more concise and effective model, and they also demonstrated that the cross-lagged model of college students' interpersonal trust, family capital, and physical activity behavior, constructed in this study, exhibited a good fit. Consequently, the M8 model was selected as the optimal representation of the relationship between the three variables and is presented in Fig. 10. To ascertain whether the gender factor exerts an influence on the model, a multi-cluster analysis test was conducted. The paths X1→Y2 and Y1→X2 were renamed a1 and b1, respectively. The statistical validation using the Bootstrap method yielded a result of $\Delta\chi^2/df = 2.762$ and a p-value greater than 0.05, indicating that the two clusters did not exhibit a significant difference between them. Consequently, the gender constraints were not validated. It can be concluded that the gender factor did not have a significant effect on the cross-lagged model between interpersonal trust, family capital, and physical activity behavior of college students.

As indicated in Fig. 10, this study utilized the path coefficients of the cross-lagged model to investigate the interrelationships between college students' interpersonal trust, family capital, and physical activity behavior. The results demonstrated that the autoregressive path coefficients of interpersonal trust, family capital, and physical

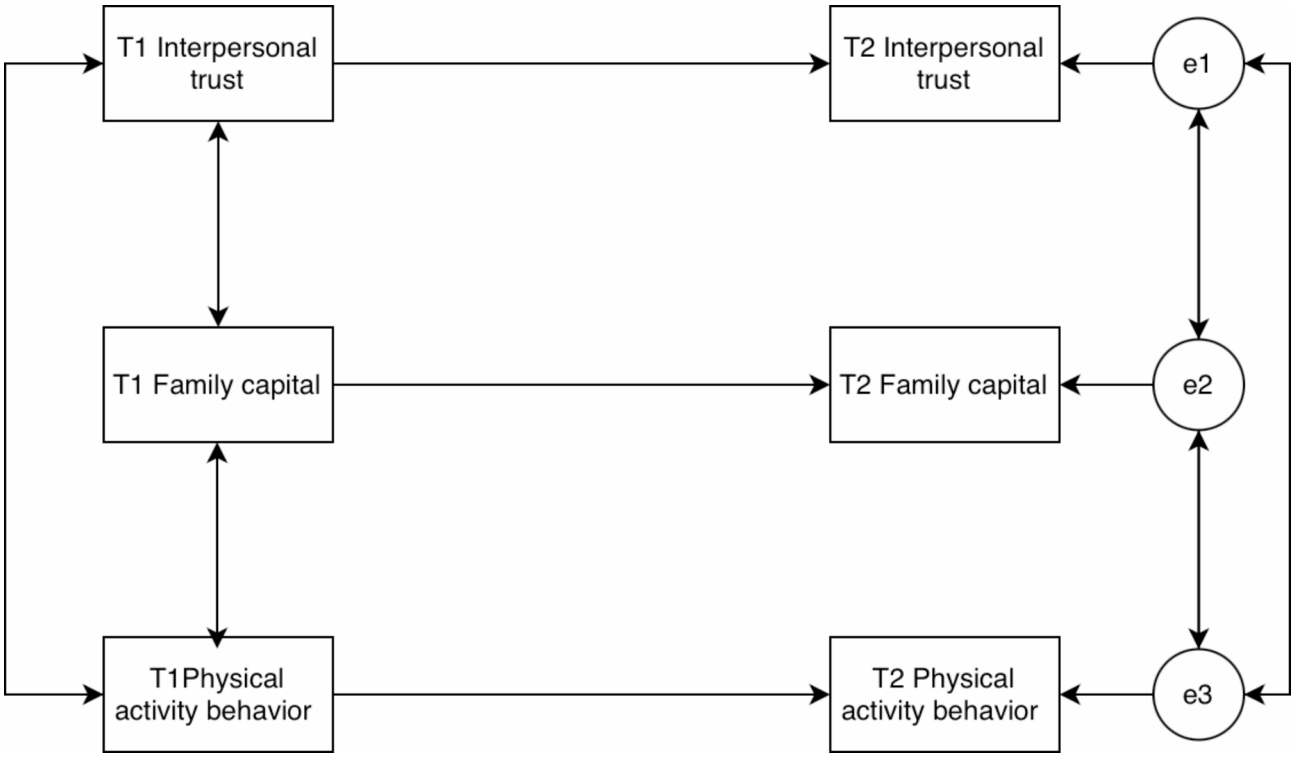

Fig. 2. M1 model diagram.

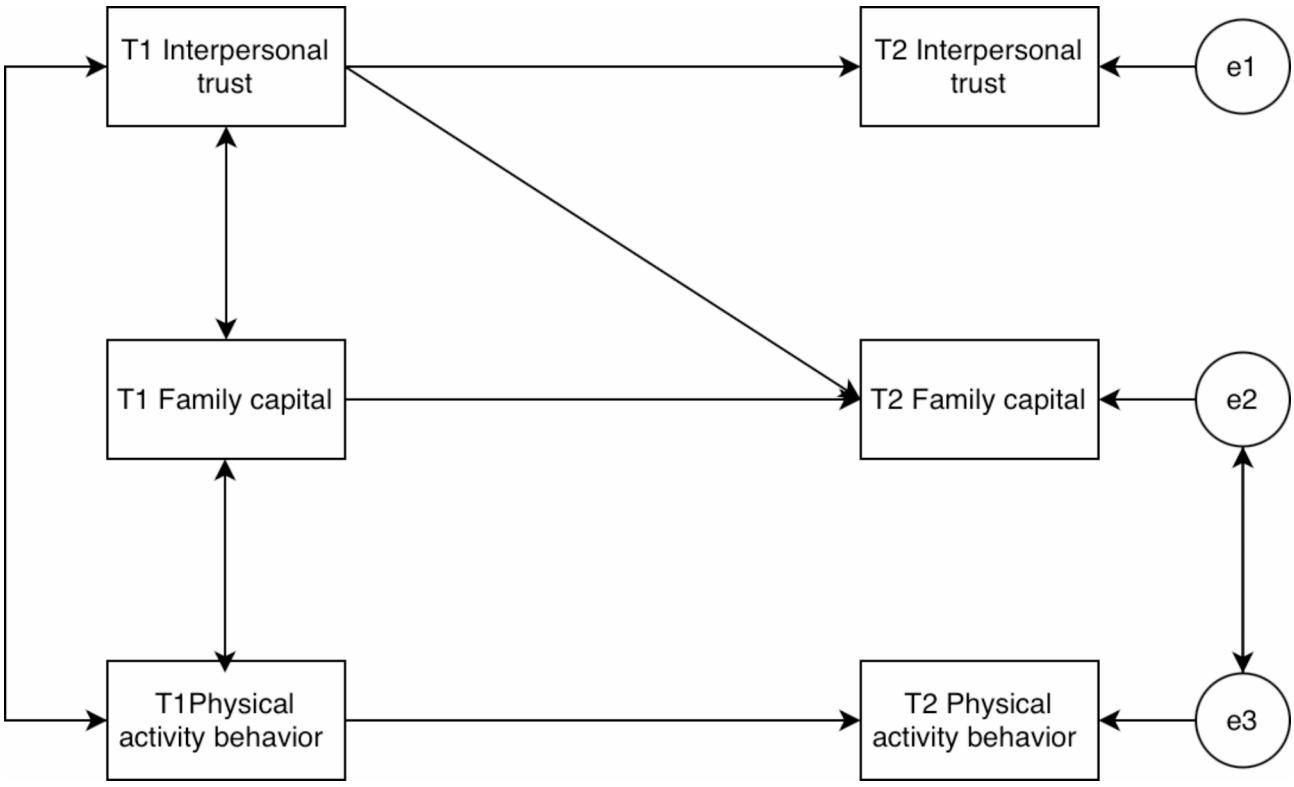

Fig. 3. M2 model diagram.

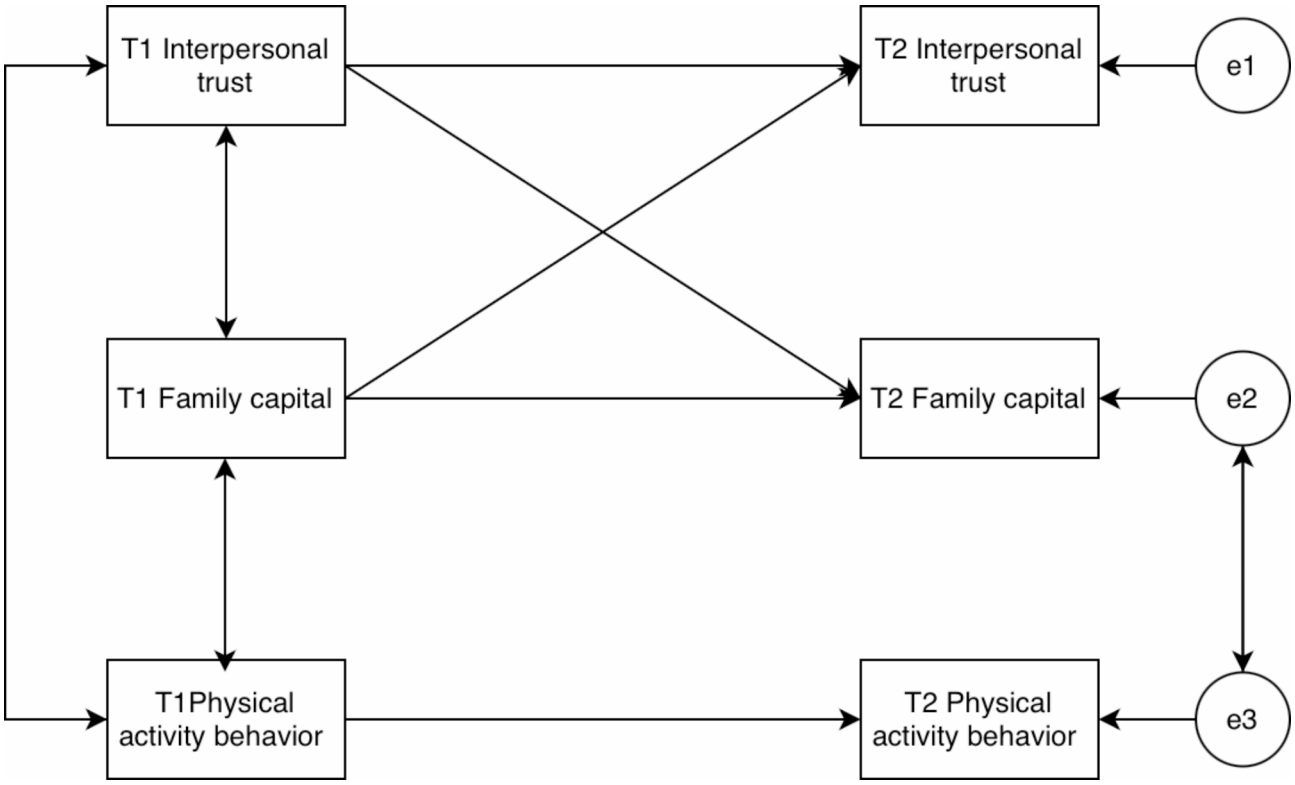

Fig. 4. M3 model diagram.

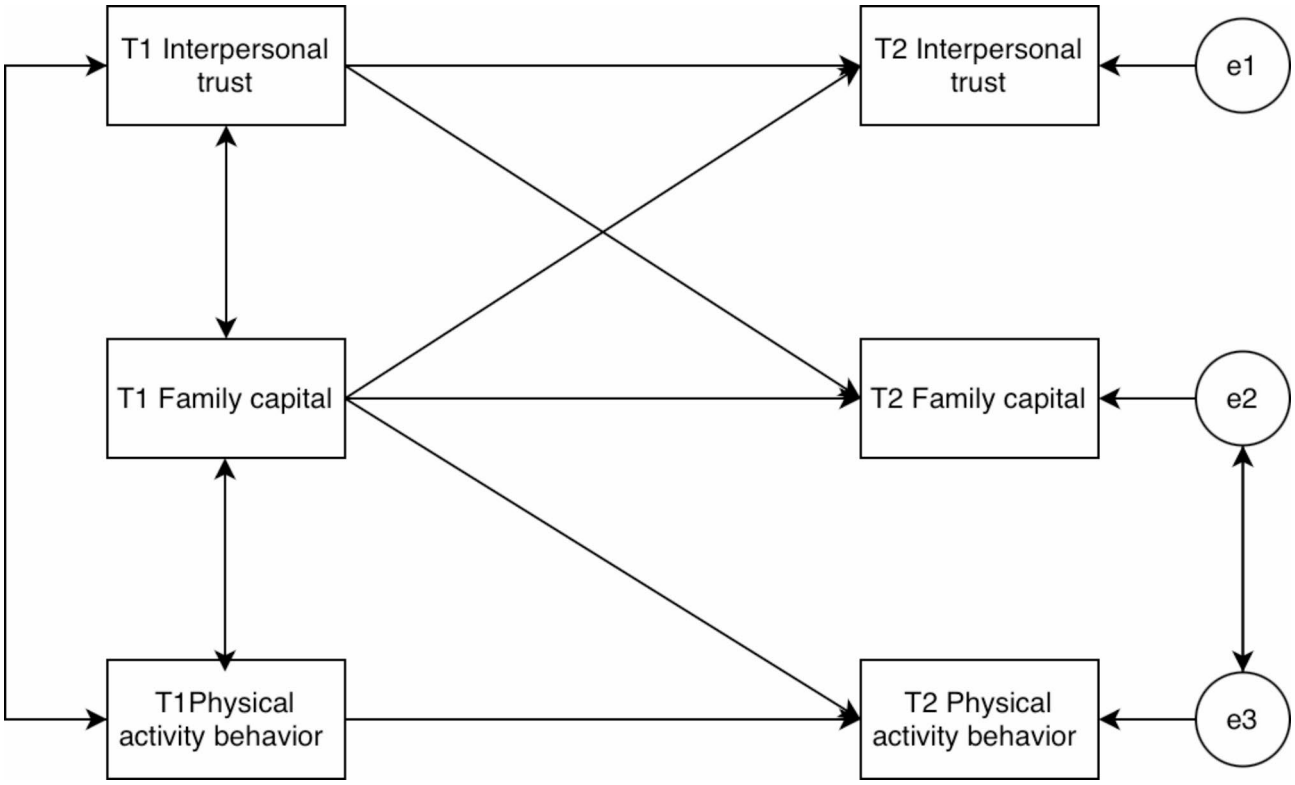

Fig. 5. M4 model diagram.

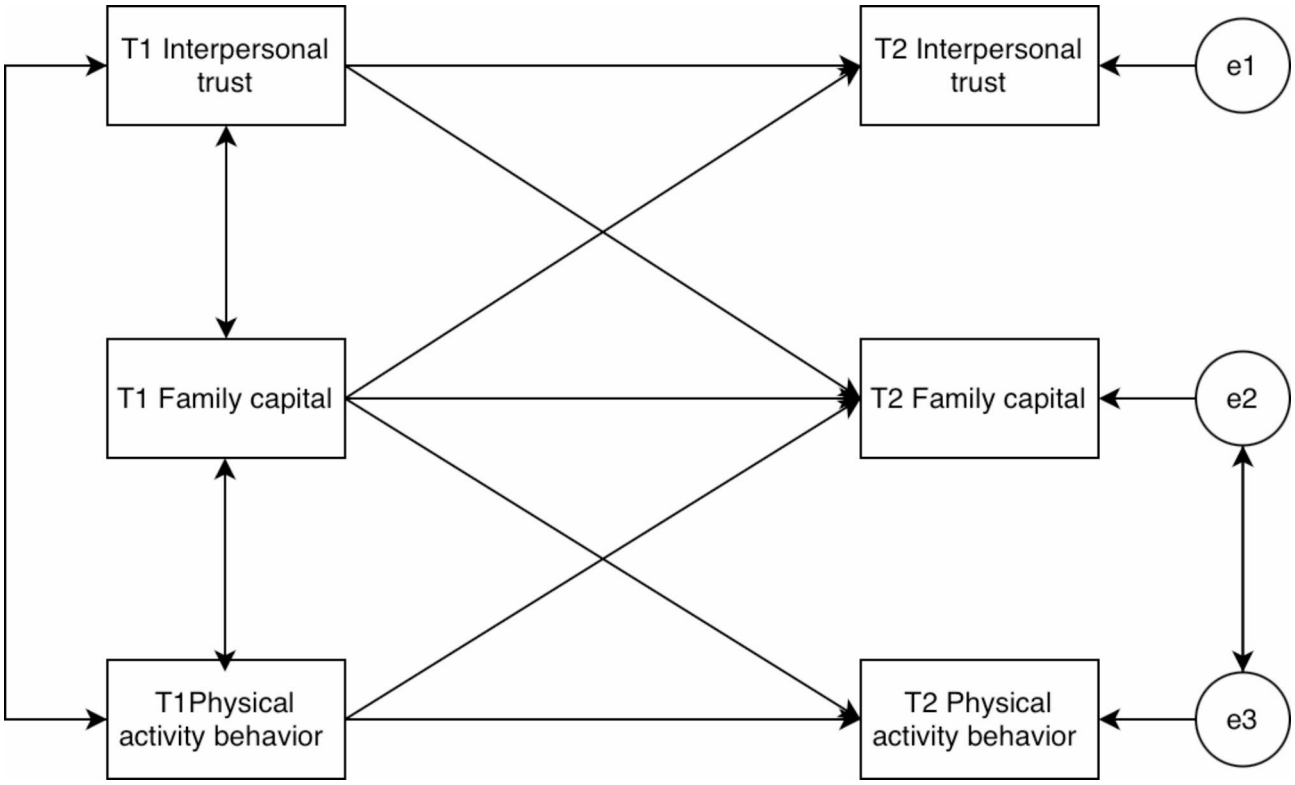

Fig. 6. M5 model diagram.

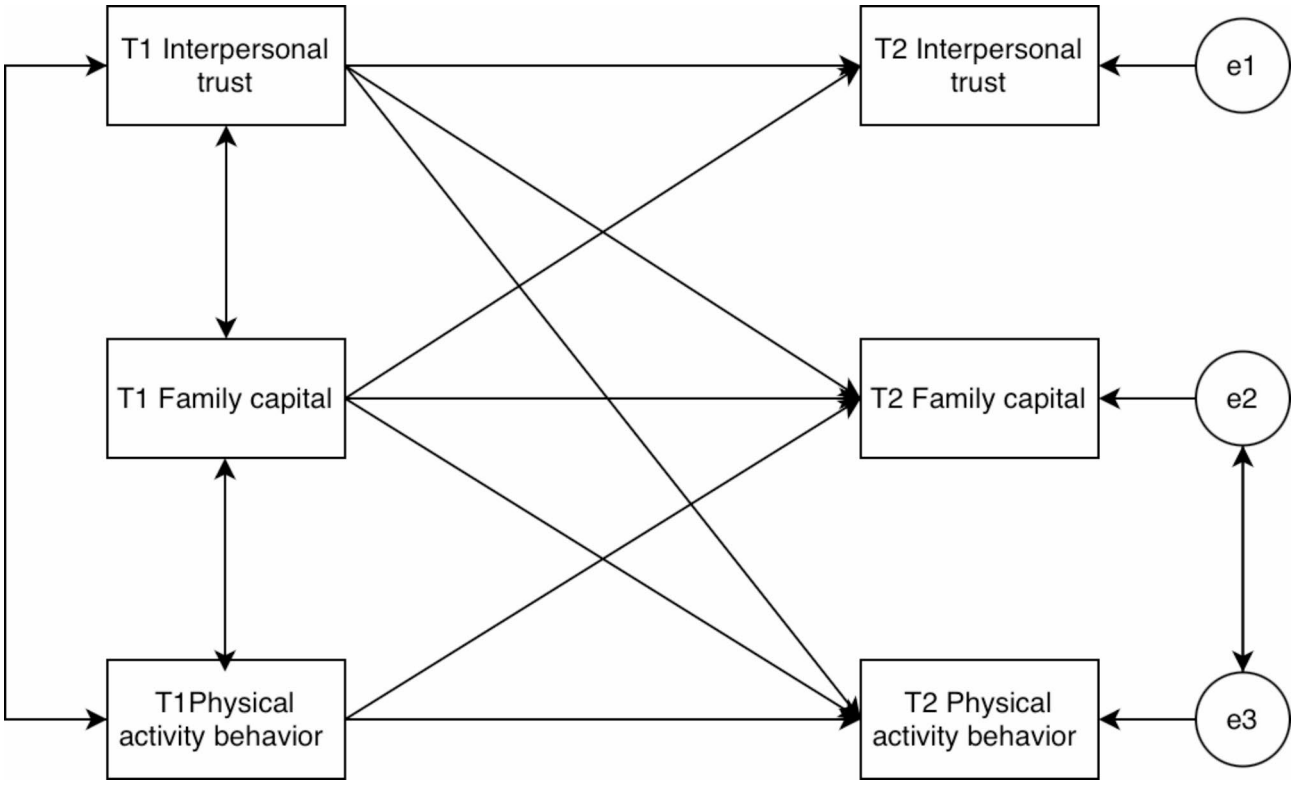

Fig. 7. M6 model diagram.

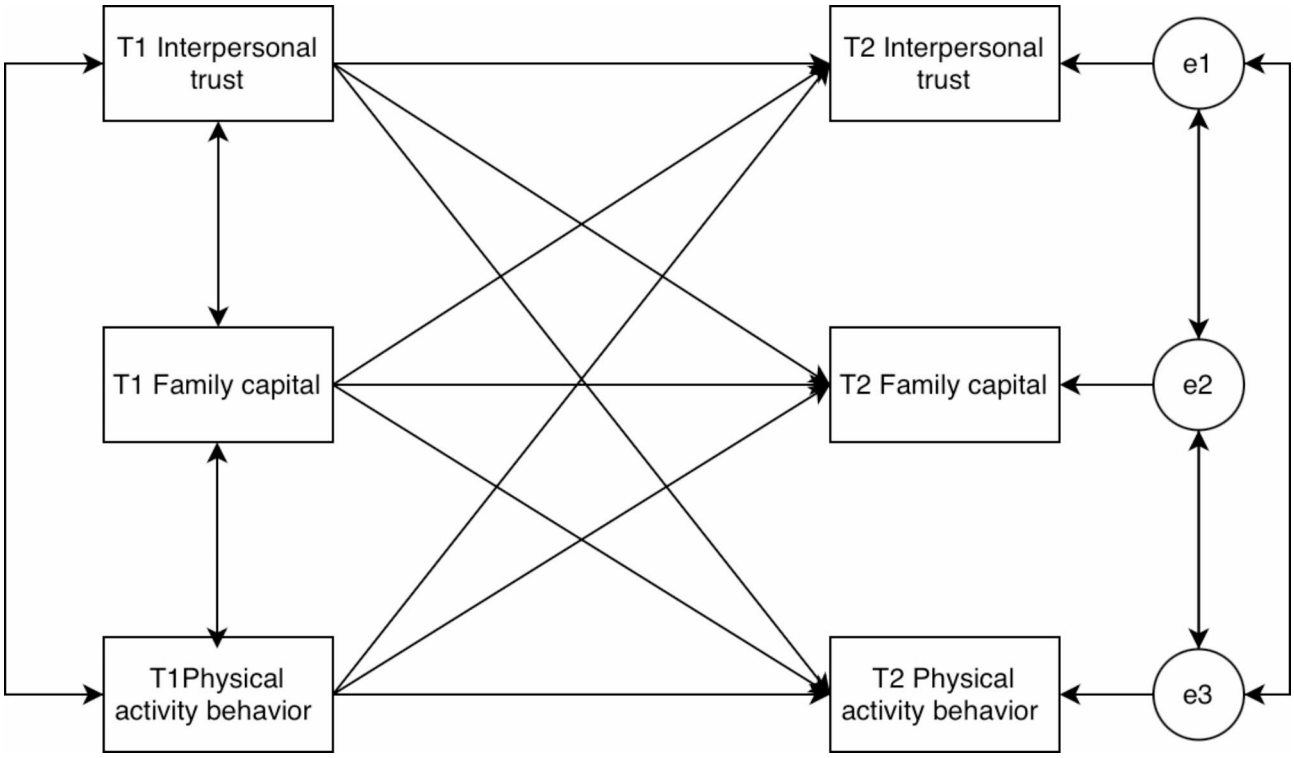

Fig. 8. M7 model diagram.

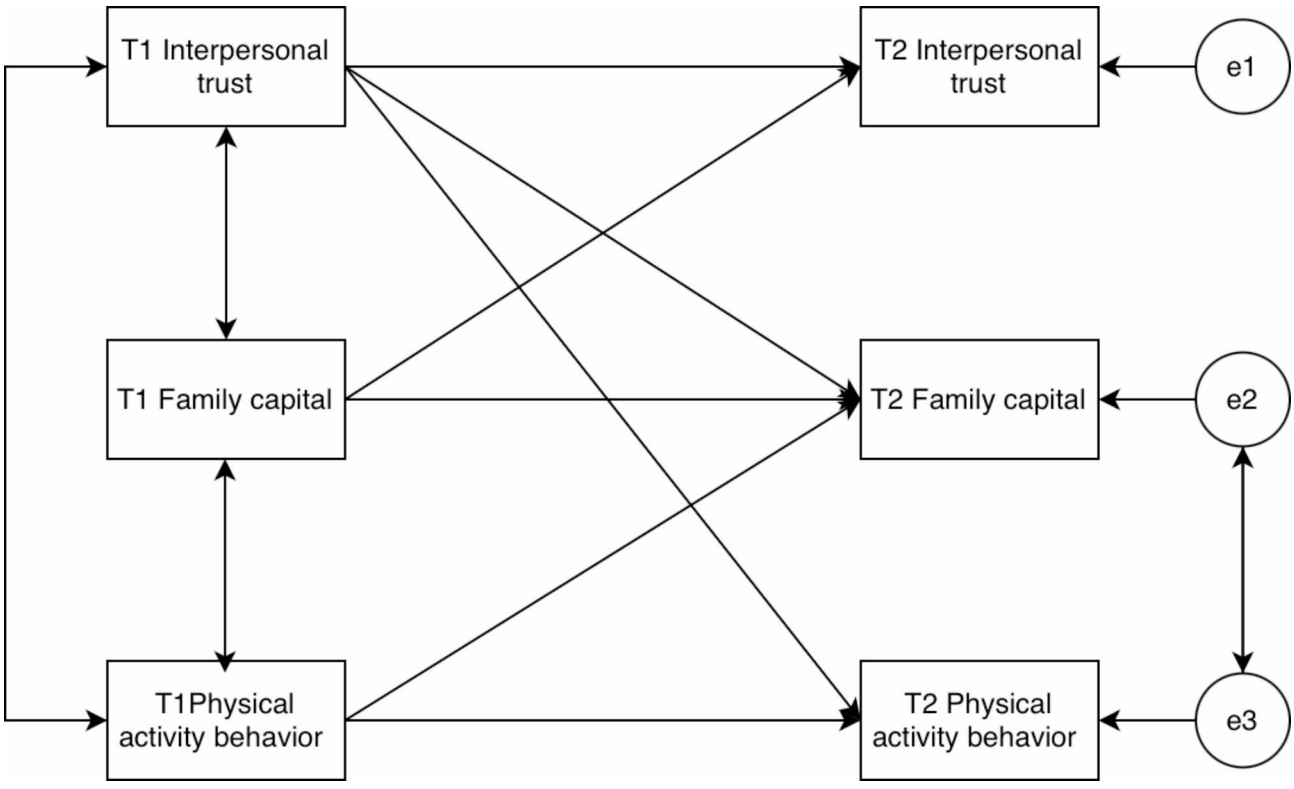

Fig. 9. M8 model diagram.

Model name	Addition of path	χ^2/df	GFI	CFI	RMSEA
M1	Baseline model	13.241	0.925	0.930	0.173
M2	X1→Y2	11.914	0.938	0.946	0.163
M3	Y1→X2	10.445	0.952	0.960	0.152
M4	Y1→Z2	10.309	0.960	0.967	0.151
M5	Z2→Y1	6.783	0.979	0.984	0.119
M6	X1→Z2	4.565	0.989	0.992	0.093
M7	Z1→X2	0.302	1.000	1.000	0.000
M8	Deletion of non-significant paths	3.424	0.989	0.993	0.077

Table 4. Indicators of goodness of fit for models M1-M8. X, Y, Z represent family capital, interpersonal trust, and physical activity behavior, with the subscript 1 representing T1 and 2 representing T2; the process of adding cross-lagged paths is such that the latter model is added on top of the former model, e.g., M2 is added on top of M1 with the path X1→Y2.

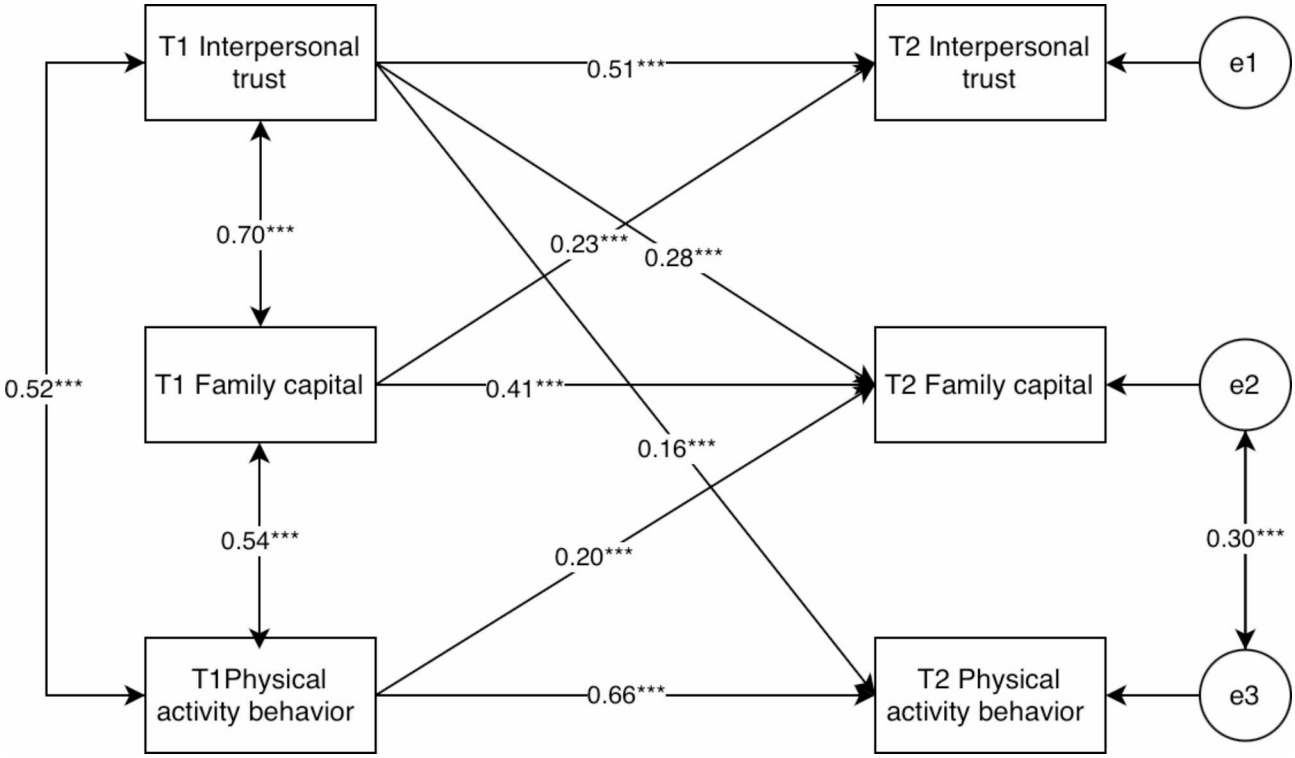

Fig. 10. Cross-lagged model of interpersonal trust, family capital, and physical activity behavior.

activity behavior were 0.51, 0.41, and 0.66, respectively, all of which exhibited significant stability ($p < 0.001$). Further analysis revealed that interpersonal trust in period T1 exhibited a positive predictive effect on family capital in period T2 ($\beta = 0.28$, $p < 0.001$), while family capital in period T1 similarly predicted interpersonal trust in period T2 ($\beta = 0.23$, $p < 0.001$). Consequently, it can be inferred that there is a dynamic relationship between family capital and interpersonal trust. Notably, although family capital at the T1 time point did not predict subsequent physical activity behavior at the T2 time point ($p > 0.05$), physical activity behavior at T1 significantly and positively predicted subsequent family capital at T2 ($\beta = 0.20$, $p < 0.001$). The results indicate that physical activity behavior is a significant factor in the change of family capital and can be considered a causal variable of family capital. Furthermore, interpersonal trust at the T1 time point was found to significantly and positively predict physical activity behavior at the T2 time point ($\beta = 0.16$, $p < 0.001$). This suggests that individuals with higher levels of interpersonal trust are more likely to maintain or increase their physical activity behavior. Nevertheless, the predictive effect of physical activity behavior at the T1 time point on interpersonal trust at the T2 time point was not statistically significant ($p > 0.05$), indicating that physical activity behavior may not be a primary driver of changes in interpersonal trust. Consequently, it can be posited that interpersonal trust is a causal variable of physical activity behavior.

Analysis of vertical mediation effects

According to the test of longitudinal mediating effect size of Wen Zhonglin et al.[60] (2022), the mediating effect of college students' family capital between social support and physical activity behavior was analyzed across time. In AMOS 26.0, the bootstrap method was employed, with a sample size of 2000 selected and a 95% confidence interval set. Based on the cross-lagged model M8, set T1 family capital→T2 interpersonal trust as c1, T1 physical activity behavior→T2 family capital as c2, T1 interpersonal trust→T2 family capital as a1, and T1 interpersonal trust→T2 physical activity behavior as b1. The path coefficient between T1 family capital and T2 interpersonal trust is 0.231 with a confidence interval of [0.094, 0.367], while the path coefficient between T1 physical exercise behavior and T2 family capital is 0.198 with a confidence interval of [0.059, 0.332]. The product of the longitudinal mediating effects c1*c2 is 0.046 with a confidence interval of [0.014, 0.097], and the significance level is $p < 0.01$, indicating that the longitudinal mediating effect is significant.

Discussion

The relationship between family capital and physical activity behavior among college students

The results of this study indicated a positive correlation between family capital and physical activity behavior during the same period. However, subsequent cross-lagged analysis revealed that family capital was not a causal variable in college students' physical activity behavior. Consequently, hypothesis 1a was not supported. This result differs from previous studies in this field[32,61]. Previous research has only explored the role of family capital on physical activity from a cross-sectional perspective, without conducting longitudinal follow-up studies. Based on this, this study introduces the variable of interpersonal trust to further analyze the mechanisms between interpersonal trust, social support, and physical activity behavior. The findings of this study indicate that family capital does not directly predict physical activity behavior. This may suggest that the association between interpersonal trust, family capital, and physical activity behavior is more complex than previously thought. Further investigation revealed that college students' physical activity behavior was a causal variable of family capital, thereby supporting Hypothesis 1b. This finding is consistent with existing research. Participation in physical activity at the college level facilitates the development of both physical and mental capabilities. Furthermore, the dissemination of the value of physical activity to one's family upon returning home strengthens the bonds and interactions within the family unit. This phenomenon provides substantial evidence in support of the hypothesis that physical activity can positively influence parent-child relationships (thereby enhancing family social capital)[34]. Consequently, the findings of this study indicate that college students' active participation in physical activity not only has a significant impact on their own overall development, but also has the potential to significantly enhance family social capital, thereby promoting the harmonious and stable development of family relationships.

The relationship between interpersonal trust and physical activity behavior among college students

This study demonstrated the substantial impact of interpersonal trust on physical activity behavior among college students, therefore corroborating the veracity of Hypothesis 2a. As posited by the social capital theory of sport, physical activity frequently occurs in intergroup interactions and exchanges[62]. The formation of intergroup trust is a gradual process that occurs over time through repeated interactions[63]. Furthermore, the homogeneity theory posits that individuals are more likely to interact with those who share similar characteristics, and that such interactions often result in convergence on certain behaviors[64]. In summary, enhanced interpersonal trust between individuals is associated with increased interactions, which in turn leads to an increase in joint participation in physical activity. Consequently, it can be posited that interpersonal trust exerts a positive predictive effect on physical activity behavior over time.

However, the study found that physical activity behavior is not a causal variable of interpersonal trust, Hypothesis 2b was not supported, which is different from previous studies[65,66]. This result can be further elucidated in accordance with the tenets of cognitive theory. The primary condition for the formation of interpersonal trust is the individual's knowledge and perception of the members of the in-group[67]. This indicates that although physical activity can facilitate the expansion of interpersonal network relationships, it does not directly determine the establishment of interpersonal trust[68]. In other words, physical activity behavior is not a significant predictor of interpersonal trust, and therefore Hypothesis 2b is not valid. It is possible that physical activity behavior may indirectly affect interpersonal trust through the influence of a mediating variable.

The relationship between family capital and interpersonal trust among college students

This study revealed the positive predictive effect of college students' family capital on interpersonal trust, thus confirming the validity of Hypothesis 3a. And it is in line with the observations of many previous researches[69,70], all of which have emphasized the strong link between interpersonal trust and family background, as well as the potential intergenerational transmission properties of such trust44. In the theoretical framework of social capital, the accumulation and construction of trust among members within an organization is a gradual process that unfolds over an extended period of time. This is achieved through communication and frequent interactions[63]. This theory is not confined to the organizational domain; in fact, it is equally applicable in the family environment. It has been demonstrated that family interpersonal capital, particularly intimacy among members, plays a pivotal role in shaping interpersonal trust[71]. Given the extended periods of time that family members spend together and interact with each other, family capital is able to transcend temporal boundaries and has a positive and long-lasting predictive effect on trust among family members.

Additionally, the study revealed that interpersonal trust among college students had a positive predictive effect on family capital, thereby substantiating the validity of Hypothesis 3b. Previous research has indicated that

interpersonal trust is considered the cornerstone of interactions and plays a crucial role in the establishment and maintenance of healthy social relationships46. Furthermore, interpersonal trust is also crucial in the family environment, as it plays a pivotal role in facilitating interpersonal interactions and fostering relationships within the family. Indeed, it has been demonstrated that there is a significant correlation between interpersonal trust and family social capital, which encompasses family trust and family support[72]. As previously stated, the majority of previous studies have focused on the predictive role of family capital in interpersonal trust43,45. However, there has been a lack of discussion on how interpersonal trust mitigates the impact of family capital. Rotter[56] (1967) highlighted that interpersonal trust encompasses both general trust and specific trust. The latter pertains to trust in family members. College students typically exhibit higher levels of trust in family members and peers, and they naturally hold more optimistic expectations regarding family social capital, such as family support and family closeness. Consequently, interpersonal trust among college students is positively correlated with family capital.

The relationship between family capital, interpersonal trust, and physical activity behavior among college students

This study provides a thorough analysis of the longitudinal mediating effects among college students' family capital, interpersonal trust, and physical activity behavior. Although a direct predictive relationship was not found between family capital and physical activity behavior, and between physical activity behavior and interpersonal trust, this study revealed an indirect link between them. Specifically, family capital served as a mediator between physical activity behavior and interpersonal trust, a finding that supports Hypothesis 4. This suggests that while interpersonal trust does not directly contribute to physical activity behavior, it has an indirect effect on physical activity behavior through the bridge of family capital.

Social capital theory indicates that social capital—interpersonal trust, network resources, and social norms—significantly affects individual behavior. In physical activity, it enhances participation by offering vital support and opportunities[62]. Within the familial context, social capital manifests through support networks, mutual trust, and shared norms among family members. These elements can promote collaboration among individuals within the family unit and bolster their overall trust in the broader society[73]. On the other hand, ecological model theory emphasizes the influence of environmental factors on individual behavior, with the family environment being a crucial factor affecting adolescents' physical activity habits[74]. Family elements, including sports context, support for physical activities, and health awareness, can influence adolescents' physical activity behaviors, potentially through family capital[75]. Specifically, the family's economic capital offers financial support and social resources that enhance social interaction and trust, promoting physical activity. Their social capital creates opportunities for physical activity and provides support through family interactions and expanded networks. Additionally, cultural capital shapes children's physical activity habits by modeling behaviors and promoting related values. In conclusion, family capital plays an important mediating role in promoting physical activity behavior by enhancing interpersonal trust and providing resource support. Family capital exerts a direct influence on individual physical activity behaviors, while also indirectly facilitating the establishment and progression of such behaviors through the enhancement of interpersonal trust.

Strengths and limitations

To our knowledge, this is one of the first analyses of the longitudinal associations among interpersonal trust, family capital and physical activity behavior of college students in China. We use cross-lagged analysis and construct a structural equation model to elucidate the underlying mechanism of how interpersonal trust influences physical activity behavior among college students, and holds significant theoretical and practical implications for comprehending the factors that influence the physical activity behavior of college students. The evidence presented here clearly suggests the future need for a broad, multifactorial approach that focuses on behavioral, familial, and psychological factors to reduce disparities in physical inactivity.

However, there are also some limitations. This research utilized undergraduate students as the primary population for investigation, which may constrain the ability to draw causal inferences between the examined variables. Future studies should consider including participants from all youth groups, as well as increasing the sample size, to better explore the underlying mechanisms among the variables. Additionally, while investigating the relationship between interpersonal trust, family capital, and physical activity behavior, it is important to acknowledge the potential influence of other factors, such as self-perception and subjective exercise experience, on the physical activity behaviors of undergraduates. Therefore, future research should incorporate a broader range of variables to enhance the comprehensiveness of the findings. Finally, cross-lagged longitudinal analysis can provide some support for causal inferences but does not allow us to definitively infer causality, Future studies using quasi-experimental intervention design are required to validate the causal relationships between interpersonal trust, family capital, and physical activity behavior.

Conclusions

In conclusion, the results of this research suggest that there is no notable distinction in interpersonal trust, family capital, and engagement in physical activity between male and female college students. Furthermore, the study identified a bidirectional causal association between family capital and interpersonal trust. Additionally, the outcomes indicated that physical activity behavior serves as a positive causal factor for family capital. The research also showed that interpersonal trust is a positive contributing factor to physical activity behavior among college students. Lastly, the study found that family capital serves as a mediating factor between interpersonal trust and physical activity behavior. In light of the findings, it becomes imperative for educational institutions to elevate the priority of college students' physical and mental health, necessitating a collaborative endeavor between educational establishments and families. This collaboration should aim to cultivate a positive perspective on life

and instill fundamental values through tailored educational programs and guidance. Simultaneously, there is a need to bolster students' social skills and strengthen their bonds with peers, family members, and diverse social circles, thereby laying a solid groundwork for interpersonal trust. Moreover, higher education institutions must actively advocate for and inspire student engagement in athletic pursuits, recognizing that such involvement plays a pivotal role in fostering holistic development of both body and mind, ultimately paving the way for the students' future growth and prosperity.

Data availability

The raw data supporting the conclusions of this article will be made available by Y.H. (corresponding author), without undue reservation and is provided within the manuscript or supplementary information files.

Received: 10 June 2024; Accepted: 10 January 2025
Published online: 17 January 2025

References

1. Caspersen, C. J., Powell, K. E. & Christenson, G. M. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Rep.* **100**, 126 (1985).
2. Li, W. H. & Chang, C. Application of health behavior theory to the study of college students' exercise behavior. *Chin. J. Health Educ.* **34**, 445–447 (2018).
3. Chekroud, S. R. et al. Association between physical exercise and mental health in 1· 2 million individuals in the USA between 2011 and 2015: A cross-sectional study. *Lancet Psychiatry* **5**, 739–746 (2018).
4. Janssen, I. & LeBlanc, A. G. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int. J. Behav. Nutr. Phys. Act.* **7**, 1–16 (2010).
5. Lesser, I. A. & Nienhuis, C. P. The impact of COVID-19 on physical activity behavior and well-being of canadians. *Int. J. Environ. Res. Public Health* **17**, 3899 (2020).
6. He, Y. & JI, L. The study of the effects of physical exercise duration on the depressive level and psychological mediator in college students. *Sports Sci.* 58–60 (2003).
7. King, A. C. *Innovative Approaches to Understanding and Influencing Physical Activity* (Elsevier Science, 2002).
8. Guthold, R., Stevens, G. A., Riley, L. M. & Bull, F. C. Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1· 6 million participants. *Lancet Child. Adolesc. Health* **4**, 23–35 (2020).
9. Volterrani, M. & Caminiti, G. *Physical Activity and Exercise for the Prevention and Management of Cardiovascular risk and Cardiovascular Disease* Vol. 101298422 (Frontiers Media SA, 2023).
10. Zhao, R. D., Yu, J. H. & Guo, J. Y. Correlation between physical exercise and parenting styles,and psychological resilience of college students. *Chin. J. School Health* **45**, 1152–1156 (2024).
11. Wang, Z. et al. Relationship between physical activity and individual mental health after traumatic events: A systematic review. *Eur. J. Psychotraumatol.* **14**, 2205667 (2023).
12. Milton, K., Macniven, R. & Bauman, A. Review of the epidemiological evidence for physical activity and health from low-and middle-income countries. *Glob. Public Health* **9**, 369–381 (2014).
13. College students sports survey: Nearly 50% of college students exercise less than three times a week. Vol. (China Youth Net, 2023).
14. Survey on the Mental. *Health Status of College Students in 2022* (Institute of Psychology, 2023).
15. Weiss, M. R. & Smith, A. L. Friendship quality in youth sport: Relationship to age, gender, and motivation variables. *J. Sport Exerc. Psychol.* **24**, 420–437 (2002).
16. Dang, A. K. et al. Associations between internet addiction and physical activity among Vietnamese youths and adolescents. *Child Youth Serv. Rev.* **93**, 36–40 (2018).
17. Qi, Y. Q. & Zhang, Z. X. Structural shift of interpersonal trust in transitional China. *Sociol. Rev. China* **10**, 124–144 (2022).
18. Li, Y. M. & Li, Y. X. Adolescents' interpersonal competence, social inferiority and mental health: The mediating role of social adaptiveness. *J. Psychol. Sci.* **38**, 109–115 (2015).
19. Yang, J., Wang, S. J., Ji, L. & Gao, L. H. Constructing model of relationship among middle school student's sport friendship quality, physical exercise behavior and mental health. *J. Shenyang Sport Univ.* **32**, 9–13 (2013).
20. Dong, J. M., Chen, P. J. & Ouyang, L. Analysis of the sociological causes and strategy on promoting the physical fitness and health of adolescent in China. *J. Capital Univ. Phys. Educ. Sports* **26**, 226–230 (2014).
21. Hu, P. H. & Yu, F. Q. A study about the restrictive factors on physical exercise of the middle school students —An HLM model based on CEPS(2014–2015). *China Sport Sci.* **39**, 76–84 (2019).
22. Wheeler, S. The significance of family culture for sports participation. *Int. Rev. Sociol. Sport* **47**, 235–252 (2012).
23. Alvarez, E. C., Kawachi, I. & Romani, J. R. Family social capital and health–A systematic review and redirection. *Sociol. Health Illn.* **39**, 5–29 (2017).
24. Sullivan, S. M. et al. Associations of neighborhood social environment attributes and physical activity among 9–11 year old children from 12 countries. *Health Place* **46**, 183–191 (2017).
25. Lindström, M. Social capital and health-related behaviors. in *Social Capital and Health* 215–238 (Springer, 2008).
26. Bourdieu, P. The forms of capital. *Cult. Theory Anthol.* **1**, 949 (2011).
27. Hou, J. Y., Zhang, J. P., Ge, Y. & Zhu, L. T. Research on the influence of family capital and education investment on the education attainment of offspring. *J. High. Educ. Manag.* **17**, 110–124 (2023).
28. Bronfenbrenner, U. *Making Human Beings Human: Bioecological Perspectives on Human Development* (Sage, 2005).
29. Cheng, G. P., Zeng, G., Liu, Q., Feng, M. & Guo, H. X. Influence of family environment to physical activity of school children. *Chin. J. School Health* **30**, 903–904 (2009).
30. Li, X. T. & Xing, X. Y. Analysis on China urban community resident exercise behavior in the perspective of social stratification: Based on CGSS data. *J. Beijing Sport Univ.* **37**, 17–25 (2014).
31. Dollman, J. & Lewis, N. R. The impact of socioeconomic position on sport participation among South Australian youth. *J. Sci. Med. Sport* **13**, 318–322 (2010).
32. Wang, F. B. H. Family capital and parenting style: Family class differences in adolescent physical activity. *China Sport Sci.* **39**, 48–57 (2019).
33. Birchwood, D., Roberts, K. & Pollock, G. Explaining differences in sport participation rates among young adults: Evidence from the South Caucasus. *Eur. Phys. Educ. Rev.* **14**, 283–298 (2008).
34. Tian, Y., Xiao, W. & Ma, Y. M. Application of national fitness big data in China. *Sports Cult. Guide*, 48–53 (2020).
35. Zhu, Q. Y. & Sun, J. H. Influences of modern family functions on family keep-fit activities. *J. Shenyang Sport Univ.* **35**, 42–46 (2016).
36. Rotter, J. B. Generalized expectancies for interpersonal trust. *Am. Psychol.* **26**, 443 (1971).
37. Sabel, C. F. Studied trust: Building new forms of cooperation in a volatile economy. *Hum. Relat.* **46**, 1133–1170 (1993).

38. Sun, X. J., Zhao, J., Zhou, Z. K., Xie, X. C. & Tong, Y. T. The relationship between online social support and online interpersonal trust of college students': A moderated mediation model. *Psychol. Dev. Educ.* **31**, 129–136 (2015).
39. Laird, Y., Fawkner, S. & Niven, A. A grounded theory of how social support influences physical activity in adolescent girls. *Int. J. Qual. Stud. Health Well-Being* **13**, 1435099 (2018).
40. Chen, S. P. *Mechanisms of Adherence to Physical Activity Behavior: Theoretical Explorations, Measurement Instruments, and Empirical Study* (Xi'an Jiaotong University, 2008).
41. Piaget, J. *Le jugement moral chez l'enfant* (1932).
42. Zhang, H. & Dong, B. L. Influence of gender role, sport friendship and autonomous motivation on adolescent exercise adherence. *J. Tianjin Univ. Sport* **32**, 355–363 (2017).
43. Xiang, M. Q. The path of promotion on teenagers' physical exercise and health-related well-being:based on self-determination theory model. *China Sport Sci.* **33**, 21–28 (2013).
44. Bornstein, M. H., Hahn, C. S. & Haynes, O. M. Social competence, externalizing, and internalizing behavioral adjustment from early childhood through early adolescence: Developmental cascades. *Dev. Psychopathol.* **22**, 717–735 (2010).
45. Berger, N., Lewis, D., Quartagno, M., Njagi, E. N. & Cummins, S. Longitudinal associations between neighbourhood trust, social support and physical activity in adolescents: Evidence from the olympic regeneration in East London (ORiEL) study. *J. Epidemiol. Community Health* **74**, 710–718 (2020).
46. Bette, K. H. *Sociology of Sport Enlightenment: A Study of Sport and Physical Education in Modern Society* (Beijing Sport University, 2020).
47. Fan, G. Z. & Wang, H. Y. Household demographic structure and household demand for life insurance:empirical research based on the data of China household finance survey. *J. Financ. Res.*, 170–189 (2015).
48. Sorokin, P. A., Zimmerman, C. C. & Galpin C.J. A systematic source book in rural sociology. *(no Title)* (1930).
49. Kelley, H. H. & Stahelski, A. J. Social interaction basis of cooperators' and competitors' beliefs about others. *J. Pers. Soc. Psychol.* **16**, 66 (1970).
50. Mayer, R. An Integrative Model of Organizational Trust. *Acad. Manage. Rev.* (1995).
51. Dohmen, T., Falk, A., Huffman, D. & Sunde, U. The intergenerational transmission of risk and trust attitudes. *Rev. Econ. Stud.* **79**, 645–677 (2012).
52. Martin, S., Forde, C., Horgan, D. & Mages, L. Decision-making by children and young people in the home: The nurture of trust, participation and independence. *J. Child Fam. stud.* **27**, 198–210 (2018).
53. Barrera Jr, M. & Ainlay, S. L. The structure of social support: A conceptual and empirical analysis. *J. Community Psychol.* **11**, 133–143 (1983).
54. Yang, L., Du, W., Fang, P. & Jiang, Y. Influence of social emotion on prosocial behavior:the mediating effect of interpersonal trust and the moderating effect of social support. *Psychol. Res.* **17**, 132–139 (2024).
55. Liu, S. H., Li, D., Liu, X. J. & Chen, X. Y. Adolescent school maladjustment:the role of family cohesion and family-based moral emotion and responsibility. *J. Psychol. Sci.* **37**, 617–624 (2014).
56. Rotter, J. B. A new scale for the measurement of interpersonal trust. *J. Pers.* (1967).
57. Wang, L. A study on the influence of psychological capital and family capital on the employment tendency of college students. *Heilongjiang Univ.* (2017).
58. Liang, D. Q. Stress levels and their relationship with physical activity among college students. *Chin. Mental Health J.*, 5–6 (1994).
59. Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y. & Podsakoff, N. P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **88**, 879 (2003).
60. Wen, Z. L., Fang, J., Xie, J. Y. & Ouyang, J. Y. Methodological research on mediation effects in China's mainland. *Adv. Psychol. Sci.* **30**, 1692–1702 (2022).
61. Chen, P. A. Household income and parent's education:which is more important for child health? *J. Appl. Stat. Manag.* **30**, 960–966 (2011).
62. Bian, Y. J. Social capital and grassroots sport. *J. Shanghai Univ. Sport.* **44**, 1–11 (2020).
63. Fang, Y. H. & Chiu, C. M. In justice we trust: Exploring knowledge-sharing continuance intentions in virtual communities of practice. *Comput. Hum. Behav.* **26**, 235–246 (2010).
64. McPherson, M., Smith-Lovin, L. & Cook, J. M. Birds of a feather: Homophily in social networks. *Ann. Rev. Sociol.* **27**, 415–444 (2001).
65. Di Bartolomeo, G. & Papa, S. The effects of physical activity on social interactions: The case of trust and trustworthiness. *J. Sports Econ.* **20**, 50–71 (2019).
66. Qin, M. & Dong, H. J. Impact of sports outward bound to interpersonal interaction and trust of college students. *J. Shenyang Sport Univ.* **36**, 89–92 (2017).
67. Carr, S. & Fitzpatrick, N. Experiences of dyadic sport friendships as a function of self and partner attachment characteristics. *Psychol. Sport Exerc.* **12**, 383–391 (2011).
68. Feng, Z., Vlachantoni, A., Liu, X. & Jones, K. Social trust, interpersonal trust and self-rated health in China: A multi-level study. *Int. J. Equity Health* **15**, 1–11 (2016).
69. King, V. Parental divorce and interpersonal trust in adult offspring. *J. Marriage Fam.* **64**, 642–656 (2002).
70. Wang, Q. Analysis and countermeasures of interpersonal trust survey for higher vocational students. *China Adult Educ.* 126–128 (2014).
71. Zhu, Q. J., Zhang, F. & Zhong, N. Favoring relatives, favoring the sage: The influence of relationship and renqing on interpersonal trust. *J. Psychol. Sci.* **44**, 1461–1468 (2021).
72. Feng, X. G. & Wang, Q. Relationship between the family adaptability, cohesion and the interpersonal trust of undergraduates. *Med. Soc.* **24**, 75–78 (2011).
73. Coleman, J. S. Social Capital in the creation of Human Capital *. *Knowl. Soc. Cap.* 17–41 (2000).
74. Sallis, J. F. & Owen, N. Ecological model of health behavior. in *Health Behavior and Health Education: Theory* (2008).
75. Lv, H. L., Wang, K. Z. & Liu, H. Family sports environment and young children's physically active lifestyle:the mediating role of family social capital. *J. Beijing Sport Univ.* **43**, 12 (2020).

Acknowledgements

The authors would like to thank the staff and students for their assistance in carrying out the survey questionnaire. We thank the staff for helping the research team recruit participants and collect data. Lastly, we thank our participants for sharing their knowledge and experiences with us, and C.L. for the opinion on our thesis topic selection.

Author contributions

The authors B.L. designed the framework of the study, and constructed the structural equation model, analyzing the data, and wrote the manuscript. Y.H. (corresponding author) contributed to revise the article and verify the data. Xl.Z. contributed to collect and verify the data. All authors contributed to the article and approved the

submitted version.

Declarations

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-86490-1.

Correspondence and requests for materials should be addressed to Y.H.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

© The Author(s) 2025