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How family structure influences middle-school students' involvement in physical exercise and their academic achievement in China

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Increasing research attention is being paid to the factors influencing the comprehensive and healthy development of adolescents. However, few studies have specifically considered cultural contexts, including that of China. Based on public database—The China Education Panel Survey (CEPS) data, this paper takes fixed-effect model to examine the relationship between family structure and physical exercise/academic achievement of middle-school students, plus their intermediary mechanisms. The results were as follows: (1) Middle-school students in intact families displayed higher levels of physical exercise and academic achievement than those in families with one or both parents absent; (2) Family structure influenced middle-school students' development through the two mechanisms of family socioeconomic status and parental input; and (3) Fathers and mothers fulfill different roles in middle-school students' development: fathers contribute more to their involvement in physical exercise; mothers contribute more to their academic achievement. The results carry theoretical and practical implications for the development of adolescents, both in China and elsewhere.

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Introduction

The development of adolescents is an important part of the sustainable development of national economy and society. Physical health and educational development are important indicators for comprehensive evaluation of adolescent health development, and are also topics of widespread concern from all walks of life. Family is a crucial site for children's development (Xie et al., 2022; Childs et al., 2022). A family with parents and children living together best supports this process, whereas children raised in non-intact families lag in terms of their academic achievement (AA), cognition, emotions, and health behaviors (Steinbach and Augustijn, 2022; Wang et al., 2022; Wu et al., 2018). Family is considered to be an important factor affecting children's participation in physical exercise (PE), with previous research demonstrating that the PE levels of children and parents are positively correlated (Donnelly et al., 2022; Han and Zheng, 2016; Mulhall et al., 2011). Moreover, family structure has a direct impact on PE behaviors, which are transmitted by parents to children; parents who regularly participate in PE play an obvious demonstrating and guiding role (Ha et al., 2022; Wang et al., 2016). The Chinese scholars Ma (2019) suggested that the decline of family stability in China has weakened families' participation in PE.

Industrialization, urbanization, and population have caused profound changes in Chinese marriage and family structure since national reform began in the 1980s (Wu et al., 2018). First, the divorce rate soared from 0.90 to 3.15 in the 15 years since 2002, and divorce numbers rose from 1.177 to 4.374 million couples before decreasing to 3.81 million in 2018 (National Bureau of Statistics of China, 2019). Second, so-called "left-behind" children and intergenerational families have become more common in China (Gu, 2022; Duan et al., 2013; Wang, 2013). Restricted by China's household registration system, most migrant workers leave their children in rural areas: the numbers of affected children had reached 15.51 million by 2017 (Zheng et al., 2022). Moreover, intergenerational relationships, living habits, and family economic status oblige many parents to rely on grandparents for childcare (Xu, 2017; Zhang, 2020a; Zhang, 2020b). Approximately 63% of middle-school students live with their parents, about 14% live with their mothers, 4% with their fathers, and 18% with other family members (Wang et al., 2016). Consequently, the comprehensive and healthy development of these left-behind adolescent children is a serious social problem that is attracting public attention (Fan, 2022; Liu et al., 2022).

As for the relationship between family structure and adolescent development, most of the existing theoretical explanations and empirical studies are based on modern western society. Such studies based on the background of China transitional society are still relatively rare, and the analysis using national representative data is almost absent. It is of great significance to deeply explore the changing trend of family structure and its social consequences for understanding the social development of contemporary China and responding to relevant major practical problems. In addition, this study can also provide Chinese cases for international studies and provide possibilities for international comparative studies.

Literature review

Family socioeconomic status and parental input. By the end of the 20th century, Western researchers had identified two main mechanisms by which family structure influenced adolescent development: (i) family socioeconomic status (FSES) and (ii) parental input (PI) (McLanahan and Sandefur, 1994). The former attributes child development issues in non-intact families to insufficient economic resources and the latter to insufficient parental supervision and parent–child interaction. In both Asian and Western societies, the poverty rate among non-intact families is very high, and the proportion of such families in groups with lower FSES is also raised (Lin and Shen, 2022; Guetto et al., 2022; Malik et al., 2022). Furthermore, the lower the FSES, the higher the risk of divorce (Xu, 2012; Wang, 2002). Yet regardless of whether lower FSES leads to divorce or separation, or vice-versa, the incidence of non-intact families is correlated with lower family socioeconomic status. When the two-parent child-rearing pattern is broken (Fei, 1998), single parents must shoulder both paid work and housework. In China, single-parent families may also face social pressure; Wu et al. (2018) report that single-parent input into children's education, supervision, and interaction is limited compared to most dual-parent families (i.e., families with both mother and father present). In addition, FSES and PI can significantly affect children's AA, cognitive ability, and health behaviors (Zhou, 2013). We therefore assume that FSES and PI also influence the relationship between family structure and middle-school student development, which we assume will be significantly lower in non-intact families in China. However, while FSES may explain the relationship between family structure and adolescents' educational development, PI is particularly relevant to health behaviors (Hampden-Thompson, 2013; Turunen, 2013).

According to family economics theory, parental roles and responsibilities differ in terms of maximizing economic efficiency and improving the family's quality of life. Mothers and fathers are primarily responsible for the physiological and social upbringing of children, respectively. This underpins the stability of the nuclear family and the absence of either parent influences children's development. To illustrate this, we now review each parent's main roles in turn.

The father's family role. China has been influenced by Confucianism for thousands of years. Although it has always advocated "equality between men and women" and the status of women has also been greatly improved today, the division of labor in the family of "male lord outside homemaking women" has not been substantially changed (Liu, 2019). Commonly the main breadwinners, fathers' resources are directed toward accruing social capital outside the family (Xu, 2022). As children's playmates, they also teach social skills and responsibility (Sun and Li, 2022). In China, old-fashioned concepts of women's inferiority and domestic duty remain commonplace and are sustained by the greater and more refined input into child-rearing that dual parenting offers (Liu, 2022; Wang and Gan, 2022). From the perspective of economics, the opportunity cost of women's involvement in PE remains higher than that of men at present in China (Zhang and Wu, 2017) and they experience more gender discrimination regarding this activity than men. While mothers provide basic services such as housework, it is fathers who are expected to encourage their children's involvement in PE by displaying their own participation in physical exercise (Liu et al., 2022; Pan, 2022). However, this is much more difficult for single fathers, whose resources are often consumed by work and housework, reducing their interaction and involvement in their children's lives. Gu et al. (2022) found that the factors such as parental input, parent–child relationship and parental support could significantly affect the formation of children's sports literacy, thus affecting the level of children's participation in physical exercise. Therefore, lack of PI may be the main mechanism for the difference in PE levels between children of single- vs. dual-parent families.

The mother's family role. Unlike many fathers, mothers invest their time and energy in social capital within the family. Wang (2022) suggested that family social capital is the main means

whereby family economic resources and parental human capital are transmitted to children (in the form of AA, etc.). In China, mothers in dual-earner urban families are the main transmitters of family cultural capital and the chief contributors to child-rearing, homework coaching, and education-related decisions (Hong, 2022). Middle-class mothers are particularly involved in their children's school education, which may be negatively impacted by their absence (Wang and Wu, 2022). Lack of paternal financial support leaves women as both breadwinners and homemakers, reducing their ability to invest time and energy in their children's education and growth. Simultaneously, the gender gap disadvantages women in the labor market, and single-mother-headed families are often economically disadvantaged. Wang (2022) found that family socioeconomic status has intergenerational transmission effect on educational human capital. The higher the family economic status, the more resources available to children, and the family economic status is in direct proportion to the education level of children. Therefore, the lack of FSES may explain the gap in educational development between children in single- and dual-parent families.

Research questions and hypotheses

Thus, family structure appears linked to middle-school students' (i) involvement in PE and (ii) AA, with FSES and PI explaining these relationships. To investigate further, we developed three research questions and five hypotheses.

RQ1: Do middle-school students in intact families outperform those in non-intact families?

H1. In China, middle-school students in intact families (consisting solely of a mother, a father, and their children) have significantly higher levels of PE and AA than those in non-intact families (consisting of one parent or none, plus children).

RQ2: Could FSES and PI explain the relationship between family structure and the comprehensive and healthy development of middle-school students in China?

H2. After controlling for PI, there is no statistically significant difference in middle-school students' involvement in PE between single-father families and intact families.

H3. After controlling for FSES, there is no statistically significant difference in middle-school students' AA between single-mother families and intact families.

RQ3: Do the modes of the effects of the two mechanisms differ between different types of single-parent families in China?

H4. After controlling for all other factors, the involvement in PE of middle-school students who live in absent-father families (consisting of a mother and her children or children only) is significantly lower than that of those who live with a father.

H5. After controlling for all other factors, the AA of middle-school students who live in absent-mother families (consisting of a father and his children or children only) is significantly lower than that of those who live with a mother.

Methods

Data. The China Education Panel Survey (CEPS) is a large-scale, nationally representative longitudinal survey launched in the 2013–2014 academic year. Beginning with 7th and 9th-graders, it aims to explain the linkages between individuals' educational outcomes and families, school processes, communities, and social structure, studying the effects of educational outcomes through the lifecourse. CEPS belongs to the Chinese National Survey Data Archive, an economic and social data-sharing platform hosted by the country's National Survey Research Center. The CEPS data are timely and significant because they capture educational development in a period of rapid social progress in China, providing rich and invaluable data for policymakers, school administrators, and social science researchers.

CEPS uses stratified multistage sampling with probability proportional to size, randomly selecting a school-based nationally representative sample of ca. 20 000 students in 438 classrooms from 112 schools in 28 county-level units in mainland China. The open-access data were derived from items exploring the demographic characteristics of students and parents, PE, AA, family structure, FSES, PI, and parent–child interaction, among others. The most recent available data date from 2014–15 and track those students who completed the previous year's baseline survey. Data with either missing or extreme values were deleted from the 9449 student respondents, leaving 8459 student responses available.

Variables

Dependent variables. In this study, the dependent variable of middle-school students' involvement in PE was represented by the number of days and amount of time per day they spent on it, with a natural logarithm used to construct a continuous variable with a normal distribution (Hu and Yu, 2019). The other dependent variable was AA, represented by students' scores in Chinese, mathematics, and English in the fall semester midterm exams, and collected directly from the surveyed schools.

Independent variables. In this study, family structure (two-parent family, single-parent family, and family with both parents absent) is similar to parenting style (dual-parent parenting, single-parent parenting, intergenerational parenting, and others) and living arrangements (living with parents, living with father or mother, and living with grandparents or other people). Family structure was sub-categorized according to whether and how students lived with their parents, i.e., conventional dual-parent families, single-mother families, single-father families, and families with both parents absent. Following Baker (2014), FSES was measured by: (i) parents' occupational type (1 = government official, 2 = business executive, 3 = scientist, engineer, university teacher, …, 13 = retired, jobless, unemployed, or laid-off, 14 = other); (ii) educational background (1 = none, 2 = primary-school graduate, 3 = middle-school graduate, …, 8 = undergraduate degree, 9 = postgraduate degree or above); and (iii) family economic self-evaluation (1 = poor, 2 = somewhat poor, 3 = medium, 4 = affluent, 5 = very wealthy), the 2014–15 CEPS did not measure parental education level. As this was assumed to be stable, information about the respondents' parents collected in the 2013–2014 school year was used in the study. In this study, we extracted the common factors of the above variables through principal component analysis and then transformed them into a continuous variable of between 0 and 100, with higher values indicating higher FSES.

PI was measured using three indicators: (i) academic and nonacademic supervision, (ii) parent–child interaction, and (iii) family cultural capital. For academic and nonacademic supervision, CEPS uses six items (assignments and exams, school performance, social communication, dressing, time online, TV-watching time) to evaluate the degree of parental academic and nonacademic supervision. Each item has three options (1 = no

supervision, 2 = mild supervision, 3 = strict supervision), and total scores range from 6 to 18; the higher the value, the more supervision parents provided. For parent–child interaction, the students were asked four questions about how often their parents cared about and discussed school events, relationships with classmates and teachers, and other concerns, with three options (1 = never, 2 = occasionally, 3 = often). CEPS asks about students' relationships with their mothers and/or fathers, also with three options (1 = not close, 2 = general, 3 = very close). Responses were scored between 10 and 30, with higher values indicating a greater degree of parent–child interaction.

Cultural capital (Bourdieu, 1986) was measured using family cultural resources and the frequency of family participation in cultural activities. Family cultural resources include domestic assets such as desks (1 = no, 2 = yes) and the family's book collection (1 = few, 2 = less, 3 = average, 4 = many, 5 = a lot). CEPS also contains two questions about the frequency of students' participation in cultural activities with their parents (museums, zoos, and science and technology museum visits, alongside attendance at movies, concerts, sports events, etc.), with six options (1 = never, 2 = annually, 3 = biannually, 4 = monthly, 5 = weekly, 6 = more than weekly). In this study, we extracted the common factors of the four variables above through principal component analysis before transforming them into a continuous 0–100 variable; higher values represented higher family cultural capital.

Control variables. The control variables included characteristic variables related to middle-school students, such as household registration type (agriculture or non-agriculture), only child (yes or no), residence (native or non-native), number of siblings, and self-rated health status. Table 1 displays the descriptive statistical results for all variables.

Analysis. All data in this study were processed using Stata 17.0. We used regression to estimate the relationships between family structure and middle-school students' (i) involvement in PE and (ii) AA, and to test FSES and PI. Based on the CEPS data structure and inter-school heterogeneity, we used a multilevel data model assigning students and schools to the first and second layers, respectively. We made estimates via a fixed-effect model using the following equation:

$$y_{it} = \sum_{k=1}^{K} \beta_k x_{kit} + \lambda_i + \mu_{it}$$

where y_{it} is the PE or AA level of student t in school i, x_{kit} is a variable (family structure, FSES, PI, or a control variable) at level t for student k in school i, β_k is the regression coefficient of the variables at level k, λ_i is the fixed intercept, and μ_{it} is the individual-level random error term.

Table 1 Statistical results for all variables ($N = 8459$).

Variables	*M*	*SD*
Dependent		
Physical exercise	2.49	1.47
Academic achievement	230.55	80.31
Independent		
Family structure		
Mother-father family	0.62	0.45
Single-mother family	0.15	0.34
Single-father family	0.06	0.18
Family with both parents absent	0.16	0.41
Parental input		
Academic and nonacademic supervision	14.26	2.15
Parent-child interaction	22.10	3.57
Family cultural capital	48.23	23.62
Family socioeconomic status	46.10	13.27
Control		
Household registration (agriculture = 1)	0.62	0.45
Only child (yes = 1)	0.68	0.38
Residence (native = 1)	0.52	0.21
Siblings	1.09	0.66
Self-rated health status	3.98	0.97

Results

Influence of family structure on students' involvement in physical exercise. A multilevel linear regression model was used to estimate the effect of family structure on students' involvement in PE and to test how family structure acts on students' involvement in PE through the mechanisms of FSES and PI (see Table 2).

In Model 1, after controlling for individual characteristics, students' involvement in PE in dual-parent families is higher than that in single-mother families (0.64), single-father families (0.76), and families with both parents absent (0.98), and the level is statistically significant, thereby supporting H1.

Model 1 was expanded to Model 2 by including FSES as a variable. Results indicate that FSES positively affects students' involvement in PE. With no change in other factors, every 1-point increase in FSES translated to a 0.02-point increase in students' involvement in PE. The statistical significance of this result suggests that FSES partially explained the influence of family structure on students' involvement in PE. However, compared with those of Model 1, the absolute values of the regression coefficients of the three dummy variables of family structure are all slightly lower in Model 2, indicating that FSES did not explain the relationship between family structure and students' involvement in PE.

Model 3 included the three PI variables, and shows that PI positively affected students' involvement in PE. The regression coefficients of the three variables were all positive at significant levels. After controlling for the three variables, the absolute coefficients for non-intact families fell considerably, demonstrating that PI is the main mechanism connecting family structure and students' involvement in PE. The coefficient for single-father families changed from −0.76 in Model 1 to −0.34 in Model 3 and was not statistically significant, meaning that lower student involvement in PE among single-father families (Model 1) was primarily due to lower PI; H2 was therefore supported.

Model 4 added both FSES and the three PI variables to M1. When all factors were held constant, children's PE levels did not differ significantly between single-father and dual-parent families. However, the children's involvement in PE in the two types of absent-father families remained lower than that in dual-parent families. Specifically, students' involvement in PE in single-mother families and families with both parents absent was respectively 0.58 and 0.45 lower than in conventional dual-parent families, again at statistically significant levels, thereby supporting H4.

Influence of family structure on students' academic achievement. A multilevel linear regression model was used to estimate the effect of family structure on students' AA and to test its effects on students' AA as mediated by FSES and PI (see Table 3).

The Model 5 data in Table 3 show that after controlling for individual characteristics, students' AA in dual-parent families was significant and higher than in single-mother families (1.62), single-father families (4.25), and families with both parents absent (4.37) at $p < 0.01$, confirming H1.

Model 6 consisted of M5 plus the variable of family economic situation, which affected students' AA positively and significantly.

Table 2 Fixed-effect model for estimating physical exercise (PE) ($N = 8459$).

Variables	Model 1 (SE)	Model 2 (SE)	Model 3 (SE)	Model 4 (SE)
Family structure[a]				
Single-mother family	−0.64** (0.18)	−0.56** (0.19)	−0.60** (0.17)	−0.58** (0.17)
Single-father family	−0.76*** (0.31)	−0.62* (0.30)	−0.34 (0.26)	−0.33 (0.27)
Family with both parents absent	−0.98** (0.19)	−0.87** (0.20)	−0.46** (0.18)	−0.45** (0.18)
Family socioeconomic status		0.02*** (0.01)		0.03*** (0.01)
Parental input				
Academic and nonacademic supervision			0.21*** (0.02)	0.23*** (0.01)
Parent-child interaction			0.51*** (0.03)	0.50*** (0.03)
Family cultural capital			0.04*** (0.01)	0.04*** (0.01)
Control variables	—	—	—	—
Constant term	2.34*** (0.23)	2.27*** (0.25)	1.72*** (0.34)	1.68*** (0.46)
Rho	0.04	0.03	0.02	0.02
Log-likelihood	−4145.80	−4136.17	−4078.63	−4069.08

SE standard error.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a]Mother–father family as the control group.

Table 3 Fixed-effect model for estimating academic achievement (AA) ($N = 8459$).

Variables	Model 5 (SE)	Model 6 (SE)	Model 7 (SE)	Model 8 (SE)
Family structure[a]				
Single-mother family	-1.62** (0.16)	-0.52 (0.19)	-1.43** (0.16)	-0.48 (0.16)
Single-father family	-4.25** (0.30)	-3.46*** (0.28)	-3.32* (0.25)	-3.37** (0.27)
Family with both parents absent	-4.37** (0.21)	-3.01** (0.19)	-2.87** (0.17)	-2.81*** (0.17)
Family socioeconomic status		0.35*** (0.01)		0.20*** (0.01)
Parental input				
Academic and nonacademic supervision			0.28*** (0.02)	0.24*** (0.01)
Parent-child interaction			0.58*** (0.03)	0.49*** (0.03)
Family cultural capital			0.12*** (0.01)	0.08*** (0.01)
Control variables	-	-	-	-
Constant term	110.45*** (0.82)	103.36*** (1.21)	98.81*** (1.45)	85.62*** (1.64)
Rho	0.22	0.20	0.19	0.16
Log-likelihood	-4121.16	-4107.23	-4093.61	-3988.65

SE standard error.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a]Mother–father family as the control group.

With the other factors held constant, every 1-point increase in FSES increased students' AA by 0.35 at statistically significant levels. The results show that FSES mediated the link between family structure and students' AA. Compared with Model 5, the absolute values of the three virtual variable regression coefficients decreased by different amounts in Model 6. The regression coefficient for single-mother families dropped from 1.62 in Model 5 to 0.52 in Model 6 and was not significant, which shows that after controlling for FSES, the AA of students from single-mother families and dual-parent families did not differ significantly. These results confirmed that students' lower AA in single-mother families (Model 5) results from lower FSES, thereby supporting H3.

Model 7 added the three PI variables to M5. The results show that academic and nonacademic supervision, parent–child interaction, and family cultural capital positively affected students' AA. The regression coefficients for the three dummy variables of family structure all decreased slightly vs. Model 5, indicating that PI explained the effect of family structure on students' AA to a limited and secondary degree.

Model 8 consisted of both FSES and PI plus the original model (Model 5). With other factors held constant, no statistically significant difference in AA was observed between children from single-mother and dual-parent families, but the students' AA in the former was significantly lower than in the latter. Specifically, students' AA in single-father families and families with both parents absent was 3.37 and 2.81 lower than in dual-parent families, at statistically significant levels. Therefore, H5 was confirmed.

Students' involvement in physical exercise and their academic achievement. Scholars have previously investigated the relationship between students' involvement in PE and their AA from the perspectives of education, sports science, psychology, and neuroscience. Moderate PE is known to improve students' cognitive ability and their AA (Wen, 2015), but it is unknown whether AA can also boost exercise levels. To date, few relevant and comprehensive studies on this topic have been conducted in China (Li and Ji, 2016) and national data remains unexamined. We therefore used the CEPS data to investigate the AA-PE relationship and determine whether it altered the linkages between family structure, AA, and PE previously modeled.

In Table 4, the variables of students' involvement in PE and their AA have been added for mutual control. Model 9 shows that AA had a statistically significant effect on children's involvement in PE. With the other factors held constant, every 1-point rise in AA caused a 0.18-point increase in students' involvement in PE. After controlling for AA, the relationship between family structure and students' involvement in PE was consistent with Model 4. Model 10 shows that PE involvement also exerted a statistically significant effect on their AA, with every 1-point increase in PE causing a 0.22-point increase in students' AA, at

Table 4 Fixed-effect model for estimating students' involvement in PE and their AA ($N = 8459$).

Variable	Model 9–PE (SE)	Model 10–AA (SE)
Family structure		
Single-mother family	−0.53** (0.16)	−0.04 (0.16)
Single-father family	−0.24 (0.22)	−2.12** (0.27)
Family with both parents absent	−0.37** (0.17)	−1.41*** (0.17)
Family socioeconomic status	0.03 (0.01)	0.08*** (0.01)
Parental input		
Academic and nonacademic supervision	0.20*** (0.01)	0.25*** (0.01)
Parent–child interaction	0.46*** (0.03)	0.38*** (0.03)
Family cultural capital	0.03*** (0.01)	0.04*** (0.01)
Academic achievement	0.18*** (0.01)	-
Physical exercise	-	0.22*** (0.02)
Control variable	-	-
Constant term	1.23** (0.50)	21.42*** (1.35)
Rho	0.02	0.21
Log-likelihood	−4054.23	−4092.24

SE standard error.
**$p < 0.01$, ***$p < 0.001$.
Mother–father family as the control group.

$p < 0.001$. After controlling for PE, the relationship between family structure and students' AA was consistent with Model 8. Therefore, Table 4 verifies the relative robustness of each model in Tables 2 and 3.

Discussion

The results from the ten models built from the 2014–2015 CEPS data confirm our five hypotheses, with the three research questions answered as follows: (1) In China, middle-school students in intact families outperform those in non-intact families; (2) FSES and PI explain how family structure is linked to the development of middle-school students; and (3) FSES and PI affect different types of single-parent families in different ways.

First, family structure was closely associated with middle-school students' involvement in PE and their AA. Students in non-intact families lagged behind those in intact families after controlling for individual characteristics and school characteristics. The healthy development of children and adolescents requires close parental supervision, and we found that variation in family structure impacted their PE and AA markedly. These heterogeneous effects may derive from functional differences in family structure: parents in families other than intergenerational ones are not overindulgent (Brown et al., 2015; Anderson, 2014). Child-rearing in conventional dual-parent families may be more systematic and better resourced than in other family structures, with the relative abundance of time and money also more influential in children's capital accumulation as two-dimensional factors (Berger and McLanahan, 2015). In intergenerational families, grandparents may lack the education to shape adolescent PE habits or challenge sedentary behavior; in single-parent families, adolescents are more likely to have an unhealthy diet and be physically inactive; in general, the health behaviors of adolescents in dual-parent families are more positive (Feinberg et al., 2022; Quick et al., 2021). However, children from single-parent families tend to perform worse at school, are less aspirational in terms of education (Pérez-Corral and Moreno Mínguez, 2022), and experience slower cognitive development (Kroese et al., 2021) and poorer academic outcomes (Guetto et al., 2022). The generally higher incomes of dual-parent families enable access to better schools, high-quality educational technology, and extracurricular tutoring courses (Doepke et al., 2019; Park and Holloway, 2018). Moreover, two parents can invest more time in childcare (Kalil et al., 2014). Overall, maternal and paternal co-parenting is the best way to ensure children's comprehensive and healthy development, as reflected by the superior involvement in PE and AA of middle-school students from such families, while students who live in families with both parents absent achieve least on these measures.

Second, in China, family structure affects the comprehensive and healthy development of middle-school students through FSES and PI. Our results confirm that FSES is significantly and positively linked to students' AA. Clearly, higher FSES confers more opportunities for middle-school students to improve academically (Jiang, 2021; Lawson and Farah, 2017). To an extent, the present study verifies the family investment model, which holds that higher FSES equates to greater development capital for positive advancement (Duleep et al., 2020; Conger and Donnellan, 2007). The study also found that no statistically significant difference in AA existed between students in single-mother vs. dual-parent families after controlling for FSES, demonstrating the latter's importance to AA. Previous studies have shown that single-mother families are often poor and vulnerable due to the division of family property, labor market discrimination, shrinking social support, and an inadequate social security system (Gupta and Kashyap, 2020; Stack and Meredith, 2018; Damaske et al., 2017; Wu et al., 2016). Meanwhile, single-parent families in economic poverty cannot provide high-quality educational resources for their children, thereby affecting the latter's academic success (Zhang, 2020a, 2020b).

This study shows that PI exerted a significant effect on students' involvement in PE, corroborating previous research: academic and nonacademic supervision, parent–child interaction, and family cultural capital all impact adolescents' health behavior (Wu and Zhang, 2018). Moreover, parental exercise behaviors directly impact children. Specifically, the influence of parents who exercised more than three times a week on the moderate-to-vigorous physical activity (MVPA) of boys and girls in middle school was respectively 2.38 and 2.77 times greater than parents who rarely exercised (Hu et al., 2017). Meanwhile, parents who participate in PE with their children not only play obvious exemplary roles but also provide them with abundant material and cultural resources (Keyes and Wilson, 2021; Cleland et al., 2011; Toftegard et al., 2011; Jago et al., 2011). The present study shows no statistically significant difference in PE existed between students from single-father families vs. conventional nuclear families after controlling for PI, demonstrating that insufficient PI can explain the difference in PE among students from these family types. Previous research has focused on mothers in single-parent families (Kanning et al., 2020; Duriancik and Goff, 2019), but our results lead us to speculate that single fathers' double duties leave them insufficient time and energy to interact with their children, and particularly to participate with them in PE. Ultimately, children in single-father families are less involved in PE than those in conventional nuclear families (Langøy et al., 2019; Wang and Qi, 2016). These results carry important implications for both family policy and education. First, they shed light on the need to improve current social security measures and increase awareness of the economic pressures on single-parent families (particularly single mothers). Second, they point to parental responsibilities: whatever their economic situation, parents should participate actively in their children's studies and daily lives to develop their health behaviors.

Third, fathers and mothers play different roles in the comprehensive and healthy development of middle-school students. The finding that fathers' absence negatively impacted students' involvement in PE underlines their importance in this area. Similarly,

our research confirms that the absence of mother damages children's levels of AA. Previous research has demonstrated that the influence of fathers on the MVPA of boys and girls in middle school was 1.20 and 1.09 times that of mothers, respectively (Hu et al., 2017). It must be underlined that input from either parent is important: compared with doing no exercise, the influence of fathers doing PE more than three times per week on the MVPA middle school was 2.44 and 3.21 times greater for boys and girls, respectively, while that of mothers was 2.23 and 2.57 times greater (Hu et al., 2019). Nonetheless, the stronger influence of fathers on children's PE habits should be noted.

For AA, our findings corroborate previous studies showing that the absence of mothers has a negative impact (Lara and Saracostti, 2019). Generally, the study findings resonate with social capital theory and the two-parent child-rearing pattern (Gamoran et al., 2021; Yang et al., 2021). Coleman (1988) identified families' internal and external social capital as vital to children's comprehensive and healthy development. Internal social capital refers to the relationship between parents and children, as reflected in productive parent–child interaction, commitment, reciprocity, trust, etc. External social capital refers to the relationships between parents and people/institutions outside the family. Coleman reasoned that parents invest their economic and personal resources (internal social capital) into developing children's human capital (cognitive ability, AA, etc.), whereas external social capital is an important channel for cultivating children's interpersonal skills and health behaviors. Dual-parent child-rearing patterns (Fei, 1998) tend to involve mothers and fathers in physiological and social upbringing, respectively. This aligns with social capital theory, which posits that fathers invest their time and energy in building external social capital and emphasize acting as role models and cultivating their children's social skills, while maternal resources are directed to developing internal social capital and participating more in their children's education (Wu et al., 2018). Therefore, because fathers model sporting activity for their children, paternal absence will significantly reduce the intergenerational transmission of sporting participation (among other functional losses), thereby decreasing students' involvement in PE. Meanwhile, the mother is the main undertaker of homework counseling, the direct transmitter of family cultural capital, and the key decision-maker in students' education. This implicates maternal absence in the lower AA of children.

Conclusions and limitations

In summary, our research has demonstrated that FSES and PI are deeply implicated in the relationship between family structure and middle-school students' AA and involvement in PE in the Chinese context. Our findings explain how they affect different single-parent families differently and demonstrate that healthy adolescent development—particularly in the areas of PE and AA—depends on co-parenting. The study has several theoretical and practical implications. At the theoretical level, the results deepen our knowledge of how family structure interacts with FSES and PI in the course of adolescent development. They also show how family structure influences middle-school students' involvement in PE and their AA. At the practical level, the results underline the importance of maternal and paternal co-parenting to comprehensive and healthy adolescent development. In this light, China's rising divorce rate and the separation of one or both parents from their children should be combated or ameliorated by policymakers, with a focus on improving FSES in single-parent families and ensuring the availability of educational opportunities.

The study's limitations include not isolating the influence of other factors such as children's gender and family location (urban vs. suburban), whose effects on the stability of influential mechanisms could be explored in future research. Second, adolescent development is not limited to PE and AA: future studies could thus investigate the influence of family structure on other variables such as adolescents' psychosocial development or cognitive ability.

Data availability

Some or all data, models, or codes that support the findings of this study are available from the corresponding author upon reasonable request.

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Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not applicable. This study used the China Education Panel Survey (CEPS) data, and this data is fully open to the academic community. (http://ceps.ruc.edu.cn/English/Home.htm).

Informed consent

The consent was deemed not necessary. This study used the China Education Panel Survey (CEPS) data, and this data is fully open to the academic community. (http://ceps.ruc.edu.cn/English/Home.htm).

Additional information

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