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The mediating effect of depressive symptoms on the association between childhood friendship and physical function in middle-aged and older adults: Evidence from the China Health and Retirement Longitudinal Study (CHARLS)

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Abstract

Purpose

This study examines the extent to which depressive symptoms mediate the link between childhood friendship (CF) and physical function among middle-aged and older adults in China.

Methods

The data originated from the China Health and Retirement Longitudinal Study. The Sobel test and multivariable logistic regression were performed to examine the mediating role of depressive symptoms (measured by the 10-item Center for Epidemiologic Studies Depression Scale) in the association between CF (measured by a standardized retrospective questionnaire) and physical function, which was measured by basic activities of daily living (BADL) disability, instrumental activities of daily living (IADL) disability, and grip strength.

Results

A total of 12,170 participants aged 45 or older were included in this cross-sectional study. After controlling for covariates, worse CF was associated with an increased prevalence of BADL disability (OR = 1.18; 95% CI = 1.05–1.32), IADL disability (OR = 1.25; 95% CI = 1.12–1.40), and low grip strength (OR = 1.21; 95% CI = 1.09–1.34). The proportion of the mediating effect of depressive symptoms was 49% in CF and BADL, 41% in CF and IADL, and 12% in CF and grip strength. Depressive symptoms and worse CF have a joint effect on BADL disability (OR = 3.30; 95% CI = 2.82–3.85), IADL disability (OR = 3.52; 95% CI = 3.03–4.09), and low grip strength (OR = 1.65; 95% CI = 1.43–1.92).

Conclusions

Adults with better CF were more likely to have a decreased prevalence of impaired physical function in their later lives. Depressive symptoms acted as a mediator associated with the development of CF. Interventions focusing on the improvement of CF and depression may help improve physical function in adults.

Introduction

Physical function is the ability to perform both basic and instrumental activities of daily living (ADL), and the ability of older adults to reside in the community depends to a large extent on their level of physical function [1]. Physical function in older adults could be reflected by the basic activities of daily living (BADL), instrumental activities of daily living (IADL), and grip strength [2]. The BADL scale represents the most basic activities involved in daily independent functioning, such as bathing, dressing, and eating [3]. IADL described activities necessary for adaptation, including community activities such as shopping, cooking, transportation, and housekeeping [3]. Additionally, grip strength is an objective measure of upper body strength and has been demonstrated to decline with age [4]. Impaired physical function can lead to increased mortality and hospitalization rates and is significantly associated with falls, dependence, and cognitive decline [4–6]. In China, more than 40 million older adults are currently suffering from impaired physical function, and this number is expected to reach 65 million by 2030 [7]. Therefore, by investigating factors associated with the development of long-term physical function among older adults, interventions focusing on the improvement of physical function in adults could be developed.

Childhood experiences have a far-reaching influence across the entire life span and adverse childhood experiences play an important role in the development of physical function in later life [8]. Previous studies have demonstrated that poor economic status, being abused, and being neglected during childhood were associated with decreased physical function

later in life [9]. However, there is a dearth of empirical studies assessing whether and how childhood friendship (CF) affects impaired physical function in middle-aged and older adults.

Depression is a common psychiatric disorder among middle-aged and older adults, affecting an estimated 322 million people worldwide [10]. According to data from baseline data of the China Health and Retirement Longitudinal Study, 30% of men and 45% of women aged 45 and above in China suffered from depression [11]. This indicates that depression has become a prominent problem and a serious disease burden for society in China [12].

Meanwhile, accumulating studies have indicated that worse CF contributes to depression, in both young and old adults. Rebecca A Schwartz-Mette et al., in a study of young adults, showed that friendship problems can elicit depressive symptoms linked to hopelessness and helplessness [13]. Another study demonstrated that those who had lower CF scores were significantly associated with a higher risk of depressive symptoms in 13,354 Chinese individuals aged 45 + years [14]. Furthermore, depression has been inversely related to the level of physical function in older people [15, 16]. A 3-year follow-up study in the United States comprising 3,421 participants found that depression was an independent risk factor for impaired physical function [17]. Similar results were reported in a Japanese American population-based survey of older adults [15]. However, the extent to which and how depressive symptoms affect the association between CF and physical function in middle aged and older adults is unclear and thus is investigated in this study.

Therefore, by using a nationally representative sample that provided both contemporaneous and retrospective data in China, this study was performed with the aim of investigating the associations between CF and physical function among Chinese middle-aged and older adults, and sought to further reveal the mediating role of depressive symptoms in the association between CF and physical function and the joint effect of depressive symptoms and CF in this association.

Materials And Methods

Participants

Data were derived from the China Health and Retirement Longitudinal Studies (CHARLS), a publicly available dataset and a national longitudinal survey of Chinese community-dwelling adults [18]. Using a sample method of multistage stratified probability-proportionate-to-size, CHARLS offered a wide range of information on adults over age 45 recruited from approximately 10,000 households in 28 provinces, and their household demographics, socioeconomic status, family structure, and health circumstances. The information collection process used face-to-face computer-assisted interviews, with two to three years of follow-up for each respondent.

For this analysis, the life history data in 2014 and the wave of the survey in 2015 were used. The life history data were collected in a special module designed with the aim of studying the life course of the respondents by using the life history survey questionnaire. The demographic, depressive symptom and physical function information of the respondents was derived from the 2015 wave, and information about their childhood was derived from the 2014 life history module. The number of eligible respondents was 12,170 (Fig. 1).

Measurement

Assessments of childhood friendship

Friendship is a close relationship between two peers that involves mutual liking and affection [19]. According to the questionnaire released by CHARLS, three items from the life course questionnaire were used to measure friendships before the age of 17. The three questions were as follows: (i) When you were a child, did you feel lonely because you did not have friends? 1 = Often, sometimes, 0 = rarely or never (ii) When you were a child, did you have a group of good friends to play with? (1 = Often/sometimes, 0 = rarely/never) (iii) When you were a child, did you have a good friend? (0 = yes,1 = no). The

total CF score was the sum of the scores for each question, ranging from 0 to 3 [20]. We categorized the participants into the following two groups based on their CF scores: good (0 points) and poor (1–3 points).

Assessments Of Physical Function

BADL/IADL disability

The CHARLS asked respondents if they required assistance with any of the six BADLs (dressing, bathing, eating, getting into and out of bed, toileting and controlling urination and defecation) or the five IADLs (preparing a hot meal, shopping for groceries, doing housework, taking medicines and managing money). All respondents were requested to choose from four options: do not have any difficulty; have difficulty but can still do it; have difficulty and need help; and cannot do it. In our analysis, respondents who needed help (last two options) with any item were considered to have a BADL/IADL disability [7].

Grip strength

Grip strength (kilogram) was estimated by using a dynamometer (WCS-100, Nantong, China). Participants squeezed the handles as hard as possible in a standing position with their arms hanging naturally at their sides. Two measurements were taken with each hand. The average value of four measurements was used in the analysis. A grip strength of less than 18 kg for women and less than 26 kg for men was defined as low grip strength [21]. Moreover, a grip strength value of 0 or above 100 kg was considered a missing value and was not included in the analysis [22].

Assessments of depressive symptoms

Depressive symptoms were examined by the 10-item abbreviated version of the Centre for Epidemiological Studies Depression Scale (CES-D), which has been widely used [23]. The 10-items refer to the depressive feelings and behaviour of the respondents during the week before the individuals took the depression assessment. Each of the scale items evaluated a depressive symptom with an assigned value ranging from 0 to 3 (0 = less than 1 day; 1 = 1 to 2 days; 2 = 3 to 4 days; 3 = 5 to 7 days). Thus, the total score of the scale ranged from 0 to 30, with a higher score indicating a higher level of depression. A cut-off score ≥ 10 was used to identify the respondents who had significant depressive symptoms [23].

Assessments Of Covariates

The analysis included both childhood and adulthood characteristics, with the childhood characteristic measured by the question "Before you were 17 years old, what was the economic situation of your family in relation to the average family in your community/village at that time?" [9]. The demographic variables included age (years), gender (male, female), marital status (married/partnered, single or others), and educational attainment (junior high school and more, junior high school and less). Health related variables included smoking (yes, no), alcohol consumption (nonregular, regular), BMI (normal, nonnormal) [24], depressive symptoms (yes, no), and self-reported health (fair/good/very good, bad/very bad).

Statistical analysis

Frequencies and percentages were calculated for descriptive analysis. The chi-square test was used to describe the differences in the prevalence of declined physical function among different attributes in the whole sample. Logistic regression was used to analyse the relationship between CF and physical function and the joint effect of depressive symptoms and CF on this relationship (Model 1 as an unadjusted model) and an adjusted model was used for covariates (Model 2 as an adjusted model). Then, we repeated the analysis between CF and physical function stratified by participants' gender. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated and reported from the logistic models.

In addition, Baron and Kenny's path analysis [25] and Sobel test [26] were adopted to verify whether there were mediating effects of depressive symptoms between CF and physical function. Baron and Kenny's path analysis used regression to test the following four paths (Appendix Fig. 1): (1) Path c: X (independent variable) on Y (dependent variable); (2) Path a: X on M (mediating variable); and (3) Path b: X and M as predictors of Y; if these three pathways were found to be significant, the mediating effect was said to be established. (4) Path c': X and M on Y. A significant Path c' indicated partial mediation, whereas nonsignificant Path c' indicated full mediation. The significance of the mediating effect was verified by the Sobel test of mediation effect (Z). All analyses were performed using Stata software version 15. A two-sided $P < 0.05$ was considered statistically significant.

Results

Study sample characteristics

The demographic characteristics of the respondents are described in Table 1. Of the 12,170 respondents, 51.6% (6,279/12,170) were female. A total of 51.8% (6,243/12,170) of the participants were over the age of 60, and only 11.19% (1,252/12,170) of the respondents had an education level above junior high school. Furthermore, 55.92% (6,805/12,170) of the participants reported a poor friendship experience. A total of 18.39% (2,238/12,170) had a BADL disability, 20.35% (2,477/12,170) had an IADL disability and 19.66% (2,393/12,170) had low grip strength. Participants with impaired physical function were more likely to be female, over age 60, less educated, and had poor CF. Significant differences were found in impaired physical function in age, sex, education level, marital status, smoking, alcohol consumption, depressive symptoms, self-reported health status, child financial status, and CF (all $P < 0.05$).

Table 1
Characteristics of study participants, CHARLS 2015

		Depressive symptoms		BADL disability		IADL disability		Low grip	
	Total (n = 12,170)	CES-D < 10 (n = 8.074)	CES-D ≥ 10 (n = 4,096)	No (n = 9,932)	Yes (n = 2,238)	No (n = 9,693)	Yes (n = 2,477)	No (n = 9,777)	Yes (n = 2,393)
Age, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
45-60years	5,814 (48.22)	3,963 (49.46)	1,851 (45.76)	5,087 (51.66)	727 (32.90)	4,969 (51.66)	845 (34.65)	5,190 (53.49)	624 (26.51)
≥ 60years	6,243 (51.78)	4,049 (50.54)	2,194 (54.24)	4,760 (48.34)	1,483 (67.10)	4,649 (48.34)	1,594 (65.35)	4,513 (46.51)	1,730 (73.49)
Sex, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
Male	5,891 (48.41)	4,360 (54.00)	1,531 (37.38)	5,008 (50.42)	883 (39.45)	4,968 (51.25)	923 (37.26)	4,923 (50.35)	968 (40.45)
Female	6,279 (51.59)	3,714 (46.00)	2,565 (62.62)	4,924 (49.58)	1,355 (60.55)	4,725 (48.75)	1,554 (62.74)	4,854 (49.65)	1,425 (59.55)
Education, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
≥ 9 years	1,252 (11.19)	1,028 (13.92)	224 (5.88)	1,140 (12.59)	112 (5.24)	1,144 (12.95)	108 (4.58)	1,137 (12.76)	115 (5.04)
< 9years	9,941 (88.81)	6,355 (86.08)	3,586 (94.12)	7,916 (87.41)	2,025 (94.76)	7,689 (87.05)	2,252 (95.42)	7,773 (87.24)	2,168 (94.96)
Marital status, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
Married	10,694(87.87)	7,256 (89.87)	3,438 (83.94)	8,872 (89.33)	1,822 (81.41)	8,659 (89.33)	2,035 (82.16)	8,815 (90.16)	1,879 (78.52)
Non-married	1,476 (12.13)	818 (10.13)	658 (16.06)	1,060 (10.67)	416 (18.59)	1,034 (10.67)	442 (17.84)	962 (9.84)	514 (21.48)
CF categories N (%)		*P* < 0.05		*P* < 0.05		P < 0.05		P < 0.05	
Good	5,365 (44.08)	3,812 (47.21)	1,553 (37.92)	4,564 (45.95)	801 (35.79)	4,492 (46.34)	873 (35.24)	4,519 (46.22)	846 (35.35)
Poor	6,805 (55.92)	4,262 (52.79)	2,543 (62.08)	5,368 (54.05)	1,437 (64.21)	5,201 (53.66)	1,604 (64.76)	5,258 (53.78)	1,547 (64.65)
Smoking, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
Current smokers	8,368 (70.60)	5,406 (68.78)	2,962 (74.18)	6,696 (69.16)	1,672 (77.02)	6,505 (68.85)	1,863 (77.46)	6,606 (69.22)	1,762 (76.31)
Current non-smokers	3,485 (29.40)	2,454 (31.22)	1,031 (25.82)	2,986 (30.84)	499 (22.98)	2,943 (31.15)	542 (22.54)	2,938 (30.78)	547 (23.69)

Note: CF = childhood friendship, BADL = basic activities of daily living, IADL = instrumental activities of daily living, BMI = body mass index, SRH = self-report health status, CFS = childhood financial situation.

		Depressive symptoms		BADL disability		IADL disability		Low grip	
Drinking, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
Occasional	10,340(85.00)	6,725 (83.33)	3,615 (88.30)	8,352 (84.13)	1,988 (88.87)	8,130 (83.92)	2,210 (89.26)	8,258 (84.50)	2,082 (87.08)
Habitual	1,824 (15.00)	1,345 (16.67)	479 (11.70)	1,575 (15.87)	249 (11.13)	1,558 (16.08)	266 (10.74)	1,515 (15.50)	309 (12.92)
BMI, N (%)		*P* = 0.09		*P* < 0.05		*P* < 0.05		*P* = 0.28	
Normal	7,049 (58.47)	4,643 (57.93)	2,406 (59.54)	5,870 (59.48)	1,179 (53.91)	5,705 (59.16)	1,344 (55.72)	5,651 (58.23)	1,398 (59.46)
Non-normal	5,007 (41.53)	3,172 (42.07)	1,635 (40.46)	3,999 (40.52)	1,008 (46.09)	3,939 (40.84)	1,068 (44.28)	4,054 (41.77)	953 (40.54)
SRH, N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
Good or fair	9,449 (77.66)	7,015 (86.89)	2,434 (59.45)	8,273 (83.30)	1,176 (52.62)	8,145 (84.03)	1,304 (52.71)	7,912 (80.95)	1,537 (64.23)
Poor	2,718 (22.34)	1,058 (13.11)	1,660 (40.55)	1,659 (16.70)	1,059 (47.38)	1,548 (15.97)	1,170 (47.29)	1,862 (19.05)	856 (35.77)
CFS N (%)		*P* < 0.05		*P* < 0.05		*P* < 0.05		*P* < 0.05	
Better or fair	7,305 (60.15)	5,151 (63.90)	2,154 (52.76)	6,126 (61.77)	1,179 (52.94)	5,968 (61.67)	1,337 (54.20)	5,940 (60.84)	1,365 (57.35)
Worse	4,839 (39.85)	29,109(36.10)	1,929 (47.24)	3,791 (38.23)	1,048 (47.06)	3,709 (38.33)	1,130 (45.80)	3,824 (39.16)	1,015 (42.65)

Note: CF = childhood friendship, BADL = basic activities of daily living, IADL = instrumental activities of daily living, BMI = body mass index, SRH = self-report health status, CFS = childhood financial situation.

Association between CF and physical function

Table 2A reports the relationship between CF and physical function. The results adjusted for covariates showed that CF was recognized as significantly associated with physical function in adulthood. Compared with respondents who did not experience poor CF, those who did were more likely to experience BADL disability (OR = 1.18, 95% CI 1.05–1.32), IADL disability (OR = 1.25, 95% CI 1.12–1.40), and low grip strength (OR = 1.21, 95% CI 1.09–1.34). However, there was no significant difference in such an association between men and women.

The Mediating Effect Of Depressive Symptoms

Table 3 reports the mediating role of CF on physical function in later life through depressive symptoms. The Sobel test showed that CF had a direct effect on physical function as well as an indirect effect on physical function through depressive symptoms. Figure 2 presents the coefficients of the associations. The direct effects of CF on BADL disability, IADL disability, and low grip strength were 0.027 ($P < 0.05$), 0.042 ($P < 0.05$), and − 0.732 ($P < 0.05$), respectively. Moreover, the indirect effects of CF on BADL disability, IADL disability, and low grip strength were 0.026 ($P < 0.05$), 0.029 ($P < 0.05$), and − 0.095 ($P < 0.05$), respectively. The total effects of CF on BADL disability, IADL disability, and low grip strength were 0.053 ($P < 0.05$), 0.072 ($P < 0.05$), and − 0.827 ($P < 0.05$), respectively. Finally, the mediated effect ratios for depressive symptoms were 49% in CF and BADL, 41% in CF and IADL, and 12% in CF and grip strength.

Table 2
The mediating effect of depressive symptoms between CF and BADL, IADL, and grip strength

Variables	BADL	Depressive symptoms	BADL
CF	0.053***	0.756***	0.027**
Depressive symptoms			0.034***
Sobel test	0.026***(Z = 10.29)		
Goodman-1	0.026***(Z = 10.29)		
Goodman-2	0.026***(Z = 10.29)		
Indirect effect	0.026***(Z = 10.29)		
Direct effect	0.027***(Z = 2.85)		
Total effect	0.053***(Z = 5.44)		
Mediation ratio	0.488		
	IADL	Depressive symptoms	IADL
CF	0.071***	0.756***	0.042***
Depressive symptoms			0.039***
Sobel test	0.029***(Z = 10.49)		
Goodman-1	0.029***(Z = 10.48)		
Goodman-2	0.029***(Z = 10.49)		
Indirect effect	0.029***(Z = 10.49)		
Direct effect	0.042***(Z = 4.40)		
Total effect	0.072***(Z = 7.25)		
Mediation ratio	0.411		
	Grip	Depressive symptoms	Grip
CF	-0.827***	0.756***	-0.732***
Depressive symptoms			-0.125***
Sobel test	-0.095***(Z=-7.66)		
Goodman-1	-0.095***(Z=-7.64)		
Goodman-2	-0.095***(Z=-7.67)		
Indirect effect	-0.095***(Z=-7.66)		
Direct effect	-0.732***(Z=-8.76)		
Total effect	-0.827***(Z=-9.91)		
Mediation ratio	0.115		
Note: CF = childhood friendship, BADL = basic activities of daily living, IADL = instrumental activities of daily living, ***$p <$ 0.001.			
Models were adjusted for age, sex, education level, marital status, self-rated health, BMI and children's financial status.			

The Joint Effect Between Cf And Depressive Symptoms On Physical Function

Table 2B reports the association of the joint effects of CF and depressive symptoms on physical function. The results of joint effects analysis adjusted for covariates showed that participants with both poor CF and depressive symptoms had a 3.30-fold higher risk of BADL disability (OR = 3.30, 95% CI 2.82–3.85), a 3.52-fold higher risk of IADL disability (OR = 3.52, 95% CI 3.03–4.09), and a 1.65-fold higher risk of low grip strength (OR = 1.65, 95% CI 1.43–1.92) than those with neither condition.

Table 3A

Association of the CF with BADL, IADL and grip strength

	Model 1 OR (95%CI)	Model 2 OR (95%CI)
BADL		
CF categories		
Good	-	-
Poor	1.53 (1.39-1.68) **	1.18 (1.05-1.32) **
IADL		
CF categories		
Good	-	-
Poor	1.59 (1.45-1.74) **	1.25 (1.12-1.40) **
Grip		
CF categories		
Good	-	-
Poor	1.57 (1.43-1.72) **	1.21 (1.09-1.34) **

Table 3B
The joint effect of CF and depressive symptoms on BADL, IADL and grip strength

	Model 1 OR (95%CI)	Model 2 OR (95%CI)
BADL		
Good CF, Non-MDD	-	-
Poor CF, Non-MDD	1.33(1.15–1.53) **	1.13(0.96–1.32)
Good CF, MDD	3.85(3.30–4.50) **	2.68(2.25–3.20) **
Poor CF, MDD	5.49(4.79–6.28) **	3.30(2.82–3.85) **
IADL		
Good CF, Non-MDD	-	-
Poor CF, Non-MDD	1.38(1.20–1.58) **	1.16(1.00-1.36) **
Good CF, MDD	3.96(3.41–4.60) **	2.62(2.20–3.11) **
Poor CF, MDD	5.93(5.20–6.77) **	3.52(3.03–4.09) **
Grip		
Good CF, Non-MDD	-	-
Poor CF, Non-MDD	1.57 (1.39–1.78) **	1.24 (1.08–1.42) **
Good CF, MDD	1.95 (1.67–2.26) **	1.42 (1.20–1.69) **
Poor CF, MDD	2.72 (2.39–3.09) **	1.65 (1.43–1.92) **
Note: CF = childhood friendship, BADL = basic activities of daily living, IADL = instrumental activities of daily living, MDD = depressive symptoms, CI = confidence interval, - = reference, ** $p < 0.05$.		
Model 1 = unadjusted.		
Model 2 = adjusted age, sex, education level, marital status, self-rated health, BMI, depressive symptoms, and children's financial status.		

Discussion

In this national cross-sectional study in China, we found a positive association between CF and physical function in middle-aged and older individuals. This finding showed that those who had better CF were more likely to have a lower rate of impairments in physical function. It was particularly interesting that we demonstrated the mediating role of depressive symptoms on the relationship between CF and physical function in elderly individuals. Moreover, the joint effects of CF and depressive symptoms on physical function in later life were observed.

Better CF was associated with better physical function later in life. This finding was consistent with a previous study showing that early life experience can influence the health of individuals in later life [27]. This could be for several reasons. First, repeated stress in early life can cause long-term health problems, including an increasing prevalence of chronic diseases in later life, which may act as stressors of impaired physical function [28]. Second, individuals with worse CF have an increased risk of being exposed to a low socioeconomic status in adulthood, which may also be associated with impaired physical function [29]. Third, poor CF may increase the likelihood of engaging in risky behaviour in adolescence and adulthood such as smoking; and drinking, which are also possibly associated with impaired physical function [27]. Theoretically, evidence also supports that adverse environments, such as experiencing fewer positive friendship

experiences may lead to changes in gene expression and cause functional and structural changes in the brain, autonomy and immune system [30]. This finding further indicated that community-based intervention programs promoting children's friendship opportunities (e.g., interaction with friends, teamwork, and club activities) may improve the long-term physical function of individuals.

Our findings have further confirmed the mediating effect of depressive symptoms on the association between CF and the levels of physical function in middle-aged and older adults. On the one hand, a previous large study demonstrated that middle-aged and older adults in China with adverse CF were at higher risk of depressive symptoms as they aged [14]. Children who grew up in environments lacking friendships tended to be lonely and more vulnerable to psychological and emotional trauma[14]. On the other hand, depressive symptoms were demonstrated to be significantly associated with a higher prevalence of impaired physical function among middle-aged and older adults in China [31]. The reason is that people with depressive symptoms were more likely to close themselves off, which may lead to impaired role performance and interfere with self-care and mobility, as well as loss of opportunities to be socially and physically active leading to decreased physical function [32, 33]. Therefore, developing appropriate interventions for prevention and controlling the development of depressive symptoms in adults (e.g., through child companionship, social interaction, and cultivation of interests) may help reduce the decline in physical function in later life.

It is important to note that the increased risk of impaired physical function depends on the presence of adverse CF in patients with depressive symptoms, as the impaired physical function risk among positive CF participants with depressive symptoms did not increase in our findings. The potential mechanism behind the joint effect of adverse CF and depressive symptoms is unknown. This may be explained by several reasons. First, as both adverse CF and depressive symptoms are associated with the volume of the hippocampus, one might speculate that the observed excess impaired physical function risk may be related to reduced hippocampal volume [30, 34]. Second, adverse CF is associated with less physical activity, which may add to the decline in physical activity levels induced by depressive symptoms, resulting in an excess risk of impaired physical function [35]. Third, middle-aged and older adults with depressive symptoms may experience secondary psychological trauma in the process of recalling adverse CF experiences, which may aggravate depressive symptoms and result in an excess risk of impaired physical function [34, 36]. Therefore, middle-aged and older adults with coexisting adverse CF and depressive symptoms were at higher risk for impaired physical function.

Based on the results of the joint effect of depressive symptoms and CF on physical function, we further found that depressive symptoms were more strongly associated with physical function than CF in middle-aged and older adults. Compared with CF, both depressive symptoms and physical function were measured in 2015 and were less susceptible to memory bias, so the results obtained are more accurate and not weakened. Moreover, previous studies have reported a variety of mechanisms linking depression and physical function [37, 38]. Via behavioural mechanisms, depressed individuals are less likely to pay adequate attention to personal health and follow treatment regimens and are more likely to engage in risky behaviours such as smoking, drinking and physical inactivity [39]. Other contributing mechanisms could be multiple pathophysiological pathways, such as inflammation and oxidative stress, that have been found to be increased in both persons with depression and in those with poorer physical function [37].

Although our hypothesis of causality between CF and physical function is supported by life-course theory, we cannot rule out the possibility of reverse causality given our cross-sectional study design. If the relationship is indeed bidirectional, such that CF affects depressive symptoms leading to impaired physical function, and conversely, physical function affects depressive symptoms leading to more severe friendship problems, then small effects in the short term may snowball into larger practical effects over time.

Policy Implications

Our results have several health policy implications for China. First, instead of focusing on the health of specific age groups, health care policies in China should consider their long-term impacts over the life cycle. For example, the fact that childhood

health matters to achieve successful ageing, including avoidance of disability, maintenance of high physical function, and sustained engagement in social and productive activities, implies that interventions to improve elderly health should take into consideration the events in the life course, beginning in childhood. The CDC's comprehensive approach to preventing adverse childhood experiences uses multiple strategies from the best available evidence [40]. The fifth of these strategies is interventions to strengthen primary care through screening, referral and support to identify and address childhood exposure to bad friendships, thereby mitigating immediate and long-term harm and advancing trauma-informed care for children, adolescents, and adults with a history of adverse exposure to CF [41, 42].

Limitations And Strengths

Our study has several limitations. First, this study used the Baron and Kenny's classic mediation model as the primary analysis. The well-recognized analytical limitations include that this approach cannot handle exposure-mediator interactions (interaction between CF and depressive symptoms in this study). This is inevitable and may alter our findings. Therefore, further research is needed. Second, the association between CF and physical function may vary across developmental stages, from early childhood to adolescence. For example, preadolescents and adolescents may experience different friendship deficits, which may have different consequences for physical function in later life. Third, it may happen that participants with depressive symptoms report their childhood experiences differently than those without depressive symptoms. For example, depressed individuals may tend to remember negative events, which could have an impact on our results. Fourth, we were not able to control for people’s behavioural problems in childhood, genetic factors or friendship problems in adulthood that might confound the relationship between worse CF and physical function in the regression analysis. Fifth, CF in our study was measured in middle-aged and older adults, and hence was subject to recall bias. Previous research has reported the reliability of retrospective measures, which cannot be simply replaced by prospective measures [43]. Nevertheless, further studies are needed to evaluate whether prospective and retrospective CF have different associations with impaired physical function. Given the lack of longitudinal studies that span from childhood to the elderly in China, our current findings would be valuable when assessing the influence of childhood experience on later life. Finally, although we combined three items to measure the status of CF, no other details of childhood friendship questions were measured in CHARLS. We did not consider the number, quality and long-term nature of friends, all of which have been found to be associated with worse friendship outcomes[13]. Therefore, it is necessary to further investigate the effects of various CF patterns on physical function later in life.

Despite these limitations, this study has some strengths. For instance, to the best of our knowledge, this study is the first to analyse the association between CF and physical function in middle-aged and aged adults. We validated depression as a risk factor for physical function in middle-aged and older adults, and further extended the findings to childhood. Moreover, this study was a large-scale nationwide sample, data were derived from diverse regions of China, and consistent and standardized survey methods were used, so our data are representative of the middle-aged and older population in China.

Conclusions

In this study, adverse CF was demonstrated to be significantly associated with impaired physical function among Chinese middle-aged and older adults. Moreover, depressive symptoms mediated this association between CF and physical function in later life. Our findings have provided evidence for the future development of early screening programs and targeted interventions to alleviate the impact of adverse CF and depressive symptoms on quality of life in later life.

Declarations

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Author Contributions

Qingping Zeng, Jiali Ding and Raoping Tu designed and conducted the study. Huihui He, Yujia Huang and Suhang Wang analyzed the data. Yuping Li and Guangyu Lu assisted in interpreting the data. Qingping Zeng, Zhiyao Wang and Qi Chen wrote the first draft, and all authors critically edited the manuscript. All authors read and approved the final manuscript.

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Data availability

The data used and analyzed in this study are publicly available from the China Health and Retirement Longitudinal Study (http://charls.pku.edu.cn/zh-CN).

Statement of Ethics

Informed consent was signed by all participants. The institutional review board of Peking University approved this study (IRB00001052–11015).

Conflict of Interest Statement

The authors declare no conflicts of interest.

Consent to participate

All interviewees gave written informed consent before recruitment to the study.

Consent for publication

Not applicable.

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Appendix Figure 1

Appendix Figure 1 is not available with this version.

Figures

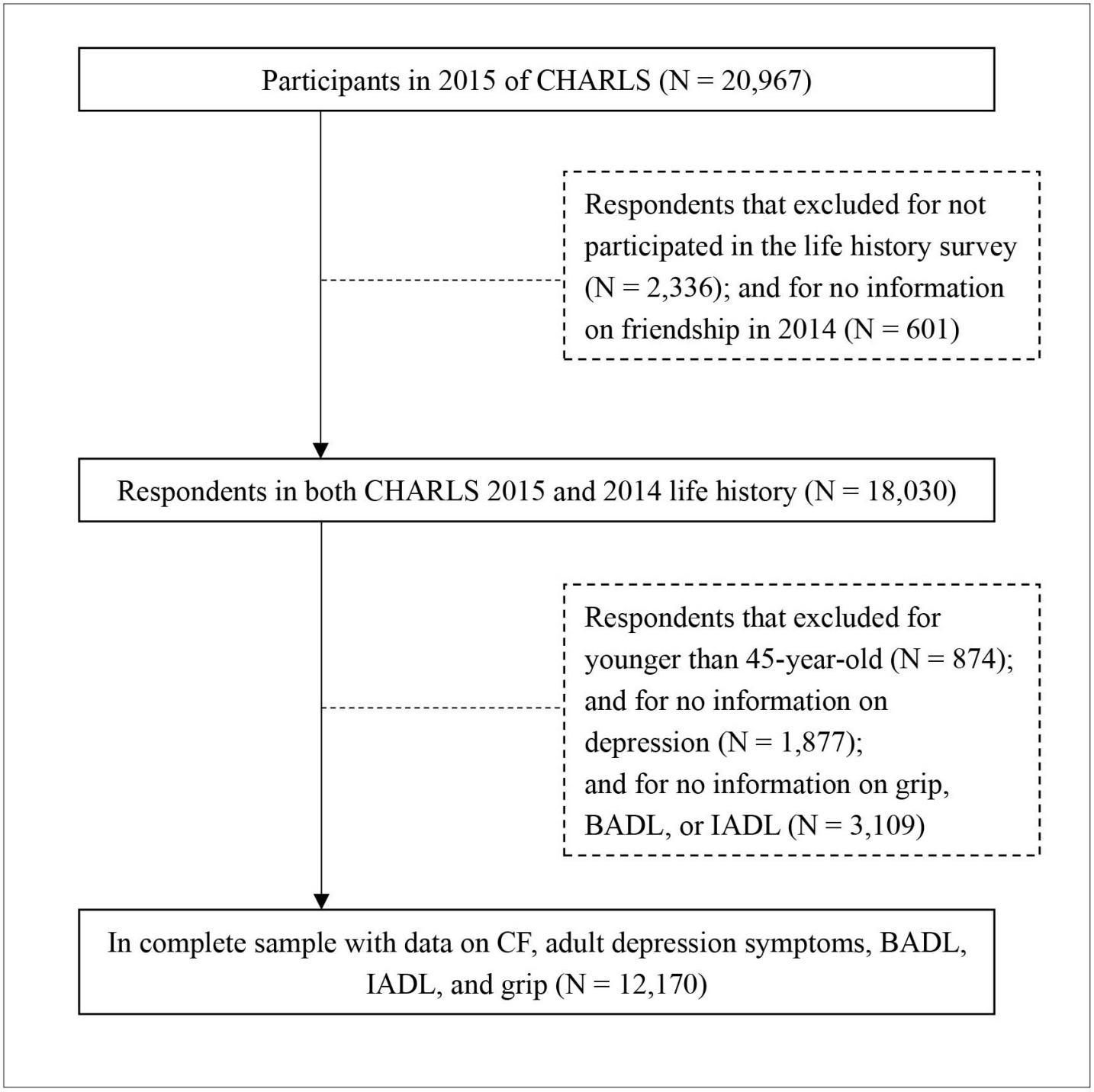


Figure 1

Flowchart of study participants

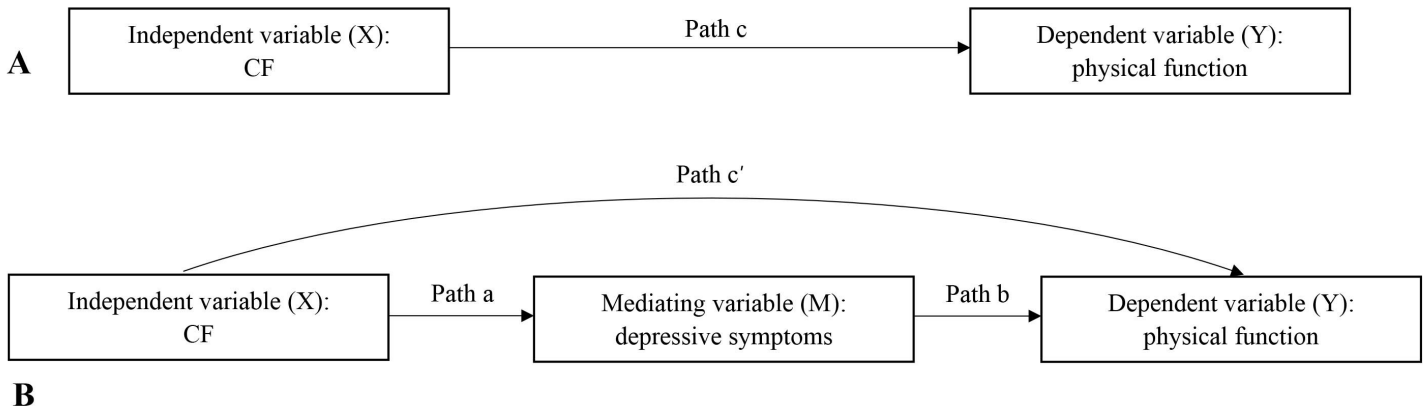


Figure 2

Diagram of paths in the hypothesized mediation model. A: Unmediated model, B: Mediation model, CF: Childhood friendship.

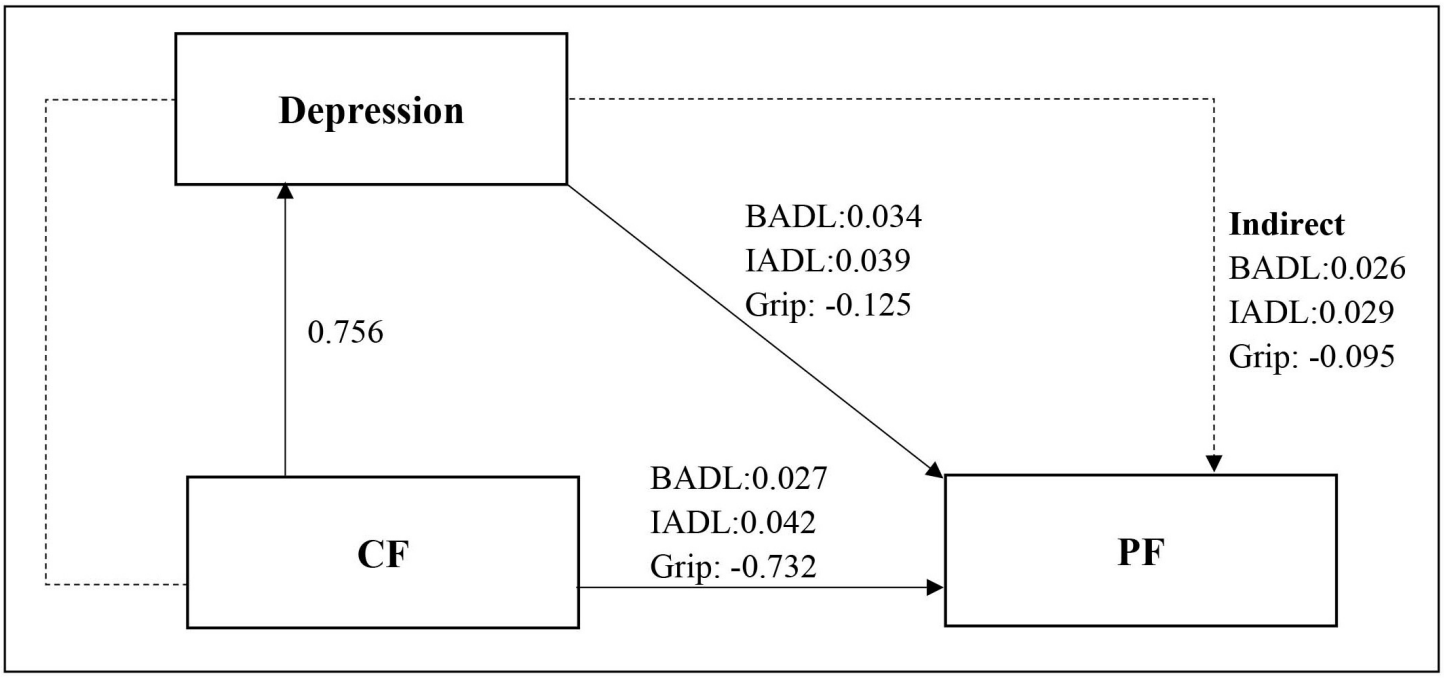


Figure 3

Mediation analysis model for direct effect (solid line), indirect effect (dashed line). CF=childhood friendship, BADL= basic activities of daily living, IADL= instrumental activities of daily living, PF=physical function (BADL disability, IADL disability, grip strength)