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Social isolation, loneliness and functional disability in Chinese older women and men: a longitudinal study

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Abstract

Objective: This study investigated whether loneliness or social isolation is associated with the onset of functional disability over 4 years among Chinese older populations.
Setting and Subjects: This study used data from the China Health and Retirement Longitudinal Study (CHARLS). Functional status was assessed by activities of daily living (ADL) and instrumental activities of daily living (IADL). Analyses were conducted with data from two waves (2011 and 2015) and were restricted to those respondents aged 50 and older and free of functional disability at baseline [n = 5,154, mean age (SD) = 60.72 (7.51); male, 52.3%].
Method: Social isolation, loneliness and covariates were measured at baseline. Follow-up measures of new-onset ADL and IADL disability were obtained 4 years later. We stratified the sample by gender, and then used binary logistic regressions to evaluate the associations between baseline isolation, loneliness and new-onset ADL and IADL disability.
Results: For women, baseline social isolation was significantly associated with new-onset ADL (OR = 1.18, 95% CI = 1.07–1.30) and IADL (OR = 1.11, 95% CI = 1.01–1.21) disability; no significant association between loneliness and ADL or IADL disability was found. For men, neither social isolation nor loneliness was found to be significantly associated with ADL or IADL disability.
Conclusion: This longitudinal study found that social isolation, rather than loneliness, was significantly associated with functional disability over 4 years among women (but not men) in China. These findings expand our knowledge about the association between social relationships and functional status among non-Western populations.

Keywords: Chinese older adults, social isolation, loneliness, functional disability, gender differences

Key Points

- It is largely unknown how social isolation and loneliness are related to functional disability in non-Western older adults.
- Whether social relationships and functional status link is particularly important for women or men is still unknown.
- Social isolation, rather than loneliness, was significantly associated with functional disability in Chinese women, but not men.

Introduction

China has the largest population of older people in the world, with a projection of over 479 million people aged 60 years or above by 2050 [1]. In parallel with this ageing profile, the number of older adults with functional disability is expected to increase to 66 million [2]. Functional capacity refers to the ability to carry out daily activities in a normal or accepted way. The most widely used measurements of functional capacity are activities of daily living (ADL) and instrumental activities of daily living (IADL). ADLs are routine activities that people do every day without needing assistance, while IADLs are higher level activities related to independent living in the community [3,4]. Functional disability is significantly associated with future falls, injury, dependency, cognitive decline and mortality [5,6].

Increasing efforts have been made to identify modifiable factors that may prevent or delay the progression of functional disability in older age. Impoverished social relationships—defined as social isolation or loneliness—have received considerable attention [7–9]. Social isolation is the objective absence of social contact and reduced social network size [5,6]. Loneliness is often defined as the subjective evaluation of social relationships which reflects the individual's dissatisfaction with the frequency and closeness of their social contacts [5,6]. Socially connected individuals can feel lonely, just as socially isolated individuals can be satisfied with their social relationships. Given weak correlations among them, isolation and loneliness may influence health through different pathways [8,9]. Emerging evidence has also indicated that these two constructs may have synergistic effects on health [10,11]. Thus, analysing both objective and subjective aspects of social relationships simultaneously can allow us to better understand how different dimensions of social relationships affect health [8,10,11].

Studies assessing the association between social relationships and physical functioning in older age have largely mixed findings. In a longitudinal study over 6-year period, a higher level of loneliness has been found to be associated with an increase of self-reported difficulties with ADL [12], while another 7-year longitudinal study failed to support the association [13]. Similarly, having a larger social network has also been linked with less decline in physical function in a longitudinal study [14], with another reporting limited or no significant associations [15]. Quite a few studies have assessed the simultaneous associations of social isolation and loneliness with functional status in older adults and results were still inconsistent. Some studies have found that both lack of social connection and loneliness were associated with poorer physical health outcomes [8,16]. A longitudinal study found that loneliness, rather than isolation, was associated with an increase in ADL difficulties [7]. It is also worth noting that most of these existing studies have focused on Western developed countries. It remains unclear to what extent the associations of social isolation and loneliness with functional disability are applied to non-Western populations.

Gender differences have also been observed in the association between social relationships and functional status

[17,18]. A systematic review conducted by Ahmadi [18] confirmed the different implications of social relationships to women's physical health and longevity compared to men's. Using prospective data from a birth cohort, Guralnik *et al*. [19] found that never married and childless married men had significantly poorer physical functions compared with married men who had children, while these associations were not observed among women. These results are inconclusive and whether social relationships and functional status link is particularly important for women or men is still unknown. Thus, our analyses were stratified by gender.

Given that very few studies examined loneliness and social isolation simultaneously in relation to functional disability in non-Western populations, and the inconclusive findings in this area, we used data from CHARLS to examine the impact of social isolation and loneliness, individually and simultaneously, on functional status over 4 years among Chinese older adults. We hypothesised that both social isolation and loneliness would be prospectively associated with new-onset functional disability over 4 years.

Methods

Participants

Data came from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is a nationally representative longitudinal survey of the middle-aged and older population (45+) in China [20]. In the current study, participants were from two waves of the CHARLS (2011 and 2015) and limited to those aged 50 and above at baseline (n = 13,649). Respondents who had missing values on any independent or control variable or ADL/IADL tests at baseline (n = 5,142) and ADL/IADL tests at follow-up (n = 1,198) were excluded. Respondents who had reported any difficulty in ADL/IADL tests at baseline (n = 2,155) were also excluded. With the selection criteria, a total of 5,154 samples were included [n = 5,154, mean age (SD) = 60.72 (7.51); male, 52.3%].

Measures

Loneliness

In our study, loneliness was measured at baseline with a single item included in the Centre for Epidemiological Studies Depression Scale (CESD): 'In the last week, how often did you feel lonely?'. The 4-point answer scale ranged from 'never' to 'always'. Despite concerns that self-reporting with a single item may lead to an underestimation of the true prevalence of loneliness, this single item approach has been widely used [21,22]. Loneliness was dichotomized into two categories (0[not lonely]=felt lonely rarely or none of the time, and 1 [lonely]=felt lonely sometimes, occasionally or most of the time) [21,22].

Social isolation

A social isolation index was derived based on six items at baseline. Participants were assigned one point if they did not get married, not have weekly contact with children in person,

not have weekly contact with children by phone/e-mail, not participate in any social activity (e.g. interacted with friends; played chess or cards; went to a sport, social or other clubs), were living in rural areas or were living alone [5,7]. Scores ranged from 0 to 6, with higher scores indicating greater social isolation.

Functional status

Functional status was measured by ADL and IADL [3,4]. CHARLS asked respondents if they required assistance with any of the six ADLs (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) [23]. In accordance with previous studies, ADL and IADL were dichotomized into no limitation or at least one limitation [13,24]. Once one or more limitations emerged at follow-up, those people would be defined as 'new-onset ADL/IADL disability' even though all participants were free of ADL/IADL disability at baseline.

Covariates

All covariates were obtained at baseline. Age, gender and education were self-reported. Education was dichotomized as lower than secondary school and secondary or above. Socioeconomic status (SES) was measured by household expenditures. Depressive symptoms were measured with the 10-item Center for Epidemiological Studies Depression Scale (CESD-10). Modified CESD scoring was used by excluding the loneliness question and calculating the sum of the remaining nine questions, which aims to yield a separate depression score (CESD-9, range 0–27). History of chronic diseases including hypertension, diabetes and heart diseases were measured with the following question: 'Have you been diagnosed by a doctor with conditions listed below?'. Body mass index (BMI) and health behaviors including drinking and smoking were collected using a standardised procedure.

Statistical analysis

Characteristics of the overall sample were described using means and standard deviations for continuous data and percentages for categorical data. We stratified the sample by gender, and then conducted Chi-square tests or independent sample t-tests to examine gender differences for baseline predictors and follow-up isolation, loneliness, new-onset ADL/IADL disability. As the household expenditures were skewed, it was log-transformed prior to analysis as previous studies [7]. To examine the association between social isolation, loneliness and functional disability for men and women, we conducted binary logistic regressions by gender. Four models were fitted. Model 1 was constructed to examine the associations between baseline loneliness and new-onset ADL/IADL disability by adjusting for all confounding variables. A similar model was then constructed for baseline social isolation (Model 2). Model 3 added both

baseline social isolation and baseline loneliness into the fully adjusted model. The interaction between baseline isolation and loneliness on new-onset ADL/IADL disability was tested by including interaction term into model 3 (Model 4). Characteristics were weighted using individual sample weights, adjusted for household and individual non-response. Regressions were run unweighted [20]. For all the regression analyses, odds ratio (OR) with corresponding 95% confidence interval (95% CI) were reported. All analyses were conducted using IBM SPSS version 23.0.

Results

Of all the population under study, 47.7% (2,460) were women and 52.3% (2,694) were men. Age ranged from 50 to 95 years, with an average of 60.72 (standard deviation [SD] = 7.51). Table 1 shows the weighted characteristics of the enrolled participants. Men and women significantly differed on most variables. At baseline, compared to men (20.7%), women (28.3%) were more likely to report feelings of loneliness ($P < 0.001$). However, no gender difference was found for social isolation (women:1.92 versus men:1.88; $P = 0.253$). At the follow-up, women had a higher proportion of loneliness than men (28.7% versus 20.4%, $P < 0.001$). Significant gender difference was also observed in the score of social isolation (women:2.12 versus men:2.02; $P = 0.018$). Additionally, women experienced a higher risk of new-onset ADL disability (20.9% versus 12.9%; $P < 0.001$) and IADL disability (25.1% versus 13.9%; $P < 0.001$) than men. Compared to those who were excluded (n = 8,495), participants who were included in the final analysis (n = 5,154) were younger, healthier and had lower levels of loneliness and isolation (all $P < 0.01$).

Table 2 lists the results of logistic regressions for new-onset ADL disability by gender. For women, baseline social isolation (OR = 1.18, 95% CI = 1.07–1.30), rather than loneliness (OR = 1.08, 95% CI = 0.85–1.37), significantly predicted ADL disability over 4 years when other confounding variables were taken into accounts. When baseline social isolation and loneliness were added into model simultaneously (Model 3), the association between social isolation and ADL disability was unchanged (OR = 1.18, 95% CI = 1.07–1.30). For men, neither baseline social isolation (OR = 0.96, 95% CI = 0.86–1.07) nor loneliness (OR = 1.12, 95% CI = 0.85–1.49) was significantly associated with new-onset ADL disability (Model 3).

Associations of baseline social isolation and loneliness with new-onset IADL disability showed a similar pattern as ADL's (Table 3). For women, baseline social isolation (OR = 1.11, 95% CI = 1.01–1.21) was significantly associated with IADL disability over 4 years, while loneliness (OR = 1.04, 95% CI = 0.83–1.31) was not in the fully adjusted model (Model 3). For men, loneliness (OR = 1.33, 95% CI = 1.02–1.75) was moderately associated with IADL disability (Model 1). However, the relationship vanished when baseline isolation and loneliness (OR = 1.31,

Table 1. Weighted characteristics of the participants by gender (n = 5,154)

Baseline characteristic	All (n = 5,154)	Women (n = 2,460)	Men (n = 2,694)	P value
Age, M (SD), y	60.72 (7.51)	60.52 (7.71)	60.91 (7.33)	0.185
Household expenditure, M (SD), yuan	23,139.94 (27,426.03)	22,464.59 (24,142.71)	23,754.64 (30,096.15)	0.140
Education level, (Less than lower secondary education, %)	87.1	91.8	82.7	<0.001
BMI, M (SD), kg/m^2	23.60 (3.83)	24.03 (4.00)	23.24 (3.64)	<0.001
Hypertension, %	27.0	29.5	24.5	0.016
Diabetes, %	6.4	7.0	5.9	0.175
Heart disease, %	12.0	13.0	11.0	0.068
Smoking, %	33.0	6.1	57.5	<0.001
Drinking, %	35.4	12.0	56.7	<0.001
CESD-9, M (SD)	6.67 (5.11)	7.42 (5.43)	5.98 (4.70)	<0.001
Baseline loneliness, %	24.3	28.3	20.7	<0.001
Baseline social isolation, M (SD)	1.90 (1.10)	1.92 (1.10)	1.88 (1.10)	0.253
Not married, %	11.4	16.0	7.2	<0.001
Less than weekly contact with children (in person), %	18.4	17.2	19.6	0.132
Less than weekly contact with children (in phone/E-mail), %	48.2	49.1	47.4	0.376
Live in the rural area, %	56.8	54.9	58.6	0.069
Not participate in social activities, %	50.3	49.3	51.2	0.320
Living alone, %	4.8	5.9	3.7	0.002
Follow-up Characteristic	All (n = 5,154)	Women (n = 2,460)	Men (n = 2,694)	P value
Follow-up loneliness, %	24.3	28.7	20.4	<0.001
Follow-up social isolation, M (SD)	2.06 (1.06)	2.12 (1.07)	2.02 (1.06)	0.018
Not married, %	14.7	21.0	9.1	<0.001
Less than weekly contact with children (in person), %	21.4	20.1	22.5	0.072
Less than weekly contact with children (in phone/E-mail), %	56.3	57.0	55.8	0.623
Live in the rural area, %	56.7	54.4	58.9	0.029
Not participate in social activities, %	52.1	52.3	52.0	0.935
Living alone, %	5.0	6.9	3.3	<0.001
New-onset ADL disability at follow-up, %	16.7	20.9	12.9	<0.001
New-onset IADL disability at follow-up, %	19.2	25.1	13.9	<0.001

M, mean; SD, standard deviation. All variables weighted at individual level with household and response adjustment except BMI. BMI is weighted by biomarker individual level with household and response adjustment.

95% CI = 1.00–1.72) were entered simultaneously into the regression model (Model 3). There is no significant association between baseline social isolation (OR = 1.08, 95% CI = 0.97–1.20) and new-onset IADL disability among men. Since no significant interaction was found (model 4), no further analysis was conducted to examine synergistic effects.

Discussion

Overall, the current study found that higher level of baseline social isolation, rather than loneliness, was significantly associated with new-onset functional disability in Chinese older adults. Further analysis showed that these associations differed between women and men. For women, social isolation was significantly associated with ADL and IADL disability, while loneliness was not. For men, neither social isolation nor loneliness was found to be significantly associated with ADL/IADL disability. No synergistic effects of isolation and loneliness on functional disability were found for either women or men.

Our findings supported the view that loneliness and social isolation might affect different aspects of health [11]: loneliness seems to be more detrimental to mental health, whereas social isolation seems to be more detrimental to cognitive and physical health. In this study, women had a higher level of social isolation than men, which is in contrast to many Western studies [17,25]. Further cross-cultural studies are warranted to clarify different mechanisms between social relationships and health in different cultural backgrounds.

Accumulated evidence has demonstrated a substantial association between low quality of objective social relationships and poor functional status in older adults. A larger social network size has been linked with less decline in physical function in some longitudinal studies [8,14,16]. Our findings were consistent with most of these studies. Additionally, clear sex-specific differences were observed in the relationship. These gender differences may be explained in several ways. First, a previous study found that men rely on spousal relationships for maintaining their functional health while women rely more on extended network members including spouse, children or others [26]. Therefore, women who had experienced social isolation had fewer opportunities

Table 2. Logistic regression for the new-onset ADL disability by gender

	Women (n = 2,460)				Men (n = 2,694)			
	Model 1 [a] + OR (95% CI)	Model 2 [b] + OR (95% CI)	Model 3 [c] + OR (95% CI)	Model 4 [d] + OR (95% CI)	Model 1 [a] + OR (95% CI)	Model 2 [b] + OR (95% CI)	Model 3 [c] + OR (95% CI)	Model 4 [d] + OR (95% CI)
Age	1.04 (1.02–1.05)***	1.03 (1.02–1.05)***	1.03 (1.02–1.05)***	1.03 (1.02–1.05)***	1.05 (1.03–1.07)***	1.05 (1.03–1.07)***	1.05 (1.03–1.07)***	1.05 (1.03–1.07)***
SES	0.87 (.66–1.14)	0.97 (.74–1.28)	0.97 (.74–1.28)	0.98 (.74–1.29)	0.82 (.60–1.12)	0.79 (.57–1.09)	0.79 (.57–1.10)	0.80 (.58–1.11)
Education	1	1	1	1	1	1	1	1
Less secondary								
Secondary and above	0.40 (.22–.71)**	0.43 (.24–.77)**	0.43 (.23–.77)**	0.43 (.24–.78)**	0.43 (.28–.66)***	0.43 (.28–.66)***	0.42 (.28–.65)***	0.42 (.27–.65)***
BMI	1.04 (1.02–1.07)***	1.05 (1.02–1.07)***	1.05 (1.02–1.07)***	1.05 (1.02–1.07)***	1.01 (.98–1.04)	1.01 (.97–1.04)	1.01 (.97–1.04)	1.01 (.97–1.04)
Hypertension No	1	1	1	1	1	1	1	1
Yes	1.29 (1.03–1.62)*	1.30 (1.03–1.63)*	1.30 (1.03–1.63)*	1.30 (1.04–1.64)*	1.23 (.94–1.62)	1.24 (.94–1.62)	1.23 (.94–1.61)	1.24 (.94–1.62)
Diabetes No	1	1	1	1	1	1	1	1
Yes	1.39 (.96–2.00)	1.42 (.98–2.05)	1.42 (.98–2.06)	1.44 (.99–2.09)	2.09 (1.37–3.18)***	2.08 (1.36–3.16)***	2.08 (1.37–3.17)***	2.10 (1.38–3.20)***
Heart diseases No	1	1	1	1	1	1	1	1
Yes	1.33 (1.00–1.76)	1.39 (1.05–1.86)*	1.38 (1.05–1.86)*	1.40 (1.05–1.86)*	1.24 (.88–1.74)	1.23 (.88–1.73)	1.23 (.88–1.72)	1.23 (.88–1.73)
Current smoker No	1	1	1	1	1	1	1	1
Yes	0.93 (.61–1.42)	0.96 (.63–1.46)	0.96 (.63–1.46)	0.97 (.63–1.47)	0.85 (.67–1.08)	0.86 (.68–1.09)	0.86 (.67–1.09)	0.85 (.67–1.08)
Alcohol consumer No	1	1	1	1	1	1	1	1
Yes	1.01 (.73–1.40)	0.99 (.71–1.36)	0.98 (.71–1.36)	0.99 (.71–1.37)	0.83 (.65–1.04)	0.82 (.65–1.03)	0.82 (.65–1.04)	0.82 (.65–1.03)
CESD-9	1.06 (1.04–1.08)***	1.06 (1.04–1.08)***	1.06 (1.04–1.08)***	1.06 (1.04–1.08)***	1.09 (1.06–1.11)***	1.09 (1.07–1.11)***	1.09 (1.06–1.11)***	1.09 (1.06–1.11)***
Loneliness No	1	-	1	1	1	-	1	1
Yes	1.08 (.85–1.37)		1.05 (.83–1.34)	1.63 (.99–2.66)	1.11 (.84–1.47)		1.12 (.85–1.49)	1.70 (.97–2.98)
Social isolation	-	1.18 (1.07–1.30)***	1.18 (1.07–1.30)***	1.26 (1.12–1.42)***	-	0.96 (.86–1.08)	0.96 (.86–1.07)	1.02 (.90–1.16)
Isolation*loneliness	-	-	-	0.82 (.68–1.00)	-	-	-	0.83 (.67–1.04)

***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$; OR = odds ratio; 95% CI = 95% confidence interval; SES is expressed as the natural log of the annual household expenditure. [a]Model 1: loneliness as predictor. [b]Model 2: social isolation as predictor. [c]Model 3: both social isolation and loneliness as predictors. [d]Model 4: model 3 + isolation*loneliness interaction. +All models were adjusted for age, SES, education, BMI, chronic diseases (hypertension, diabetes and heart diseases), healthy behaviors (drinking and smoking) and depression.

to benefit from social interaction and may develop poorer functional status. Second, many studies have indicated that the relationship between social support and health is through the buffering effect of support on stress [17,18,27]. More and more evidence shows that social support was negatively related to stress in women but not men [27,28]. Lack of social support and increased stress have been linked to less healthy behaviors including poorer diet, less exercise and impaired sleep quality [29]. Consequently, isolated women may experience higher risks of functional disability.

Studies assessing the association between loneliness and functional status produced mixed findings. Prospective findings have shown linking of loneliness with decline in gait speed or mobility [16], and increased difficulties with ADL [7]. However, an analysis of Danish adults found no significant association between loneliness and functional capability in the fully adjusted model [30]. Another 7-year longitudinal study also found that loneliness was not significantly associated with difficulty in ADL after adjusting for all control variables [13]. Similarly, in the current study, a significant association was found in primary analysis. However, these

associations were no longer significant when all confounding variables were entered into the regression models. These results implied that loneliness might be a consequence of some chronic health problems. Furthermore, the impact of loneliness on health may be overestimated if studies fail to take account of the objective social relationships [6].

The strengths of this study include longitudinal assessment and examination of the concurrent effects of social isolation and loneliness on functional disability by gender in the Chinese population. Limitations to our study exist. First, loneliness was assessed with only one direct question regarding the perception of loneliness in the last week. Despite wide use in the literature and strong correlations with several established multiple-item scales [21,22], this measure may be less reliable than a composite measure that taps multiple aspects of loneliness. Second, we excluded those with preexisting disability conditions at baseline. These exclusion criteria may have led to a positively selected sample of older adults healthier than the general ageing population. Third, the current study was limited to self-report data, which raises the potential problem of mono-method bias.

Table 3. Logistic regression for the new-onset IADL disability by gender

	Women (n = 2,460)				Men (n = 2,694)			
	Model 1 [a] + OR (95% CI)	Model 2 [b] + OR (95% CI)	Model 3 [c] + OR (95% CI)	Model 4 [d] + OR (95% CI)	Model 1 [a] + OR (95% CI)	Model 2 [b] + OR (95% CI)	Model 3 [c] + OR (95% CI)	Model 4 [d] + OR (95% CI)
Age	1.03 (1.01–1.04)***	1.02 (1.01–1.04)***	1.02 (1.01–1.04)***	1.03 (1.01–1.04)***	1.05 (1.04–1.07)***	1.05 (1.04–1.07)***	1.05 (1.04–1.07)***	1.05 (1.04–1.07)***
SES	0.83 (.64–1.06)	0.88 (.68–1.14)	0.88 (.68–1.15)	0.89 (.68–1.15)	0.64 (.47–.87)**	0.67 (.49–.92)*	0.68 (.50–.93)*	0.68 (.50–.94)*
Education								
Less secondary	1	1	1	1	1	1	1	1
Secondary and above	0.34 (.19–.60)***	0.36 (.20–.63)***	0.36 (.20–.63)***	0.36 (.20–.63)***	0.66 (.45–.95)*	0.68 (.47–.99)*	0.67 (.46–.98)*	0.67 (.46–.98)*
BMI	1.00 (.98–1.02)	1.00 (.98–1.03)	1.00 (.98–1.03)	1.00 (.98–1.03)	0.98 (.95–1.02)	0.99 (.95–1.02)	0.99 (.95–1.02)	0.99 (.95–1.02)
Hypertension								
No	1	1	1	1	1	1	1	1
Yes	1.19 (.95–1.48)	1.19 (.96–1.48)	1.19 (.96–1.48)	1.19 (.96–1.48)	1.61 (1.25–2.09)***	1.64 (1.27–2.13)***	1.63 (1.25–2.11)***	1.63 (1.26–2.11)***
Diabetes								
No	1	1	1	1	1	1	1	1
Yes	1.28 (.89–1.83)	1.30 (.91–1.86)	1.30 (.91–1.86)	1.32 (.92–1.87)	1.35 (.86–2.10)	1.35 (.87–2.11)	1.35 (.87–2.12)	1.36 (.87–2.12)
Heart diseases								
No	1	1	1	1	1	1	1	1
Yes	1.43 (1.09–1.88)**	1.48 (1.13–1.94)**	1.48 (1.13–1.94)**	1.48 (1.13–1.94)**	1.29 (.93–1.79)	1.32 (.96–1.84)	1.31 (.94–1.82)	1.31 (.95–1.82)
Current smoker								
No	1	1	1	1	1	1	1	1
Yes	0.98 (.67–1.45)	1.00 (.68–1.47)	1.00 (.68–1.47)	1.01 (.69–1.49)	0.97 (.77–1.23)	0.97 (.77–1.23)	0.96 (.76–1.22)	0.96 (.76–1.22)
Alcohol consumer								
No	1	1	1	1	1	1	1	1
Yes	0.99 (.74–1.35)	0.98 (.73–1.33)	0.98 (.73–1.33)	0.98 (.73–1.33)	0.72 (.58–.91)**	0.72 (.58–.91)**	0.73 (.58–.91)**	0.73 (.58–.91)**
CESD-9	1.07 (1.05–1.09)***	1.07 (1.05–1.08)***	1.06 (1.05–1.08)***	1.06 (1.05–1.08)***	1.07 (1.04–1.09)***	1.08 (1.05–1.10)***	1.07 (1.04–1.09)***	1.07 (1.04–1.09)***
Loneliness								
No	1	-	1	1	1	-	1	1
Yes	1.06 (.85–1.33)		1.04 (.83–1.31)	1.54 (.97–2.44)	**1.33 (1.02–1.75)***		1.31 (1.00–1.72)	1.48 (.86–2.57)
Social isolation	-	**1.11 (1.01–1.21) ***	**1.11 (1.01–1.21) ***	**1.18 (1.05–1.32) ****	-	1.09 (.98–1.21)	1.08 (.97–1.20)	1.10 (.97–1.25)
Isolation*loneliness	-	-	-	0.84 (.70–1.01)	-	-	-	0.95 (.77–1.17)

***, P < 0.001; **, P < 0.01; *, P < 0.05; OR = odds ratio; 95% CI = 95% confidence interval; SES is expressed as the natural log of the annual household expenditure. [a]Model 1: loneliness as predictor. [b]Model 2: social isolation as predictor. [c]Model 3: both social isolation and loneliness as predictors. [d]Model 4: model 3 + isolation*loneliness interaction. +All models were adjusted for age, SES, education, BMI, chronic diseases (hypertension, diabetes and heart diseases), healthy behaviors (drinking and smoking) and depression.

Fourth, there may be other unmeasured factors responsible for the associations found here. No causal conclusion can be drawn. Finally, there are only three waves available in CHARLS. It might not be enough to reveal the longitudinal change trajectories between social isolation, loneliness and functional disability. Further studies with more waves and longer times are warranted to examine the aforementioned issue by using more appropriate analysis methods like multi-level model.

In conclusion, this longitudinal study found that social isolation, rather than loneliness, was significantly associated with functional disability over 4 years in Chinese women, but not men. These findings expand our knowledge about the association between social relationships and functional status among non-Western populations.

Declaration of Conflicts of Interest: None.

References

1. United Nations, Department of Economic and Social Affairs, Population Division. World Population Ageing, 2017 Highlights, 2017. https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf (29 November 2020, date last accessed).

2. WHO. China Country Assessment Report on Ageing and Health. WHO. http://www.who.int/ageing/publications/china-country-assessment/en/ (29 November 2020, date last accessed).

3. KATZ S. The index of ADL: a standardized measure of biological and psychosocial function. J Am Med Assoc. 1963;185:914–9.

4. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. The gerontologist. 1969; 9 (3_Part_1): 179–86.

5. Shankar A, McMunn A, Banks J, Steptoe A. Loneliness, social isolation, and behavioral and biological health indicators in older adults. Health Psychol 2011; 30: 377.

6. Steptoe A, Shankar A, Demakakos P, Wardle J. Social isolation, loneliness, and all-cause mortality in older men and women. Proc Natl Acad Sci 2013; 110: 5797–801.

7. Shankar A, McMunn A, Demakakos P, Hamer M, Steptoe A. Social isolation and loneliness: prospective associations with functional status in older adults. Health Psychol 2017; 36: 179.

8. Rico-Uribe LA, Caballero FF, Olaya B *et al.* Loneliness, social networks, and health: a cross-sectional study in three countries. PloS one 2016; 11: e0145264.

9. Holt-Lunstad J, Robles TF, Sbarra DA. Advancing social connection as a public health priority in the United States. Am Psychol 2017; 72: 517.

10. Yu B, Steptoe A, Chen Y, Jia X. Social isolation, rather than loneliness, is associated with cognitive decline in older adults: the China health and retirement longitudinal study. Psychol Med 2020; 1–8.

11. Beller J, Wagner A. Disentangling loneliness: differential effects of subjective loneliness, network quality, network size, and living alone on physical, mental, and cognitive health. J Aging Health 2018; 30: 521–39.

12. Perissinotto CM, Cenzer IS, Covinsky KE. Loneliness in older persons: a predictor of functional decline and death. Arch Intern Med 2012; 172: 1078–84.

13. Stessman J, Rottenberg Y, Shimshilashvili I, Ein-Mor E, Jacobs JM. Loneliness, health, and longevity. J Gerontol A Biol Sci Med Sci 2014; 69: 744–50.

14. Buchman AS, Boyle PA, Wilson RS, Fleischman DA, Leurgans S, Bennett DA. Association between late-life social activity and motor decline in older adults. Arch Intern Med 2009; 169: 1139–46.

15. Green AF, Rebok G, Lyketsos CG. Influence of social network characteristics on cognition and functional status with aging. International journal of geriatric psychiatry: a journal of the psychiatry of late life and allied. Sciences 2008; 23: 972–8.

16. Kearns A, Whitley E, Tannahill C, Ellaway A. Loneliness, social relations and health and well-being in deprived communities. Psychol Health Med 2015; 20: 332–44.

17. Shumaker SA, Hill DR. Gender differences in social support and physical health. Health Psychol 1991; 10: 102.

18. Ahmadi A. Social Support and Women's Health. Women's Health Bulletin 2015; 3: 1–6.

19. Guralnik JM, Butterworth S, Patel K, Mishra G, Kuh D. Reduced midlife physical functioning among never married and childless men: evidence from the 1946 British birth cohort study. Aging Clin Exp Res 2009; 21: 174–81.

20. Lei X, Sun X, Strauss J *et al.* Health outcomes and socio-economic status among the mid-aged and elderly in China: evidence from the CHARLS national baseline data. JEoA 2014; 3: 29–43.

21. Rabin BS. Social networks and dementia. The Lancet 2000; 356: 76–7.

22. Teguo MT, Simo-Tabue N, Stoykova R *et al.* Feelings of loneliness and living alone as predictors of mortality in the elderly: the PAQUID study. Psychosom Med 2016; 78: 904–9.

23. Silverstein M, Gong CH, Kendig H. Perceived availability of future care and depressive symptoms among older adults in China: evidence from CHARLS. BMC Geriatr 2020; 20: 31.

24. Connolly D, Garvey J, McKee G. Factors associated with ADL/IADL disability in community dwelling older adults in the Irish longitudinal study on ageing (TILDA). Disabil Rehabil 2017; 39: 809–16.

25. McDonald S, Mair CA, eds. Social Capital Across the Life Course: Age and Gendered Patterns of Network Resources 1. Sociological Forum. Wiley Online Library, 2010.

26. Saito T, Murata C, Aida J, Kondo K. Cohort study on living arrangements of older men and women and risk for basic activities of daily living disability: findings from the AGES project. BMC Geriatr 2017; 17: 183.

27. Zhang M, Zhang J, Zhang F, Zhang L, Feng D. Prevalence of psychological distress and the effects of resilience and perceived social support among Chinese college students: does gender make a difference? Psychiatry Res 2018; 267: 409–13.

28. Beehr TA, Farmer SJ, Glazer S, Gudanowski DM, Nair VN. The enigma of social support and occupational stress: source congruence and gender role effects. J Occup Health Psychol 2003; 8: 220.

29. Uchino BN, Bowen K, de Grey RK, Mikel J, Fisher EB. Social support and physical health: Models, mechanisms, and opportunities. Principles and concepts of behavioral medicine. New York, NY: Springer; 2018. p. 341–72.

30. Lund R, Laban J, Petersen GL, Dissing A, Hansen ÅM, Rod NH. Loneliness and objectively measured physical capability in middle-aged adults. The European Journal of Public Health. 2018; 28: 16–23.