Separating the Effects of Transitions into and Out of Social Isolation and Loneliness on Cognitive Function in Later Life

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Abstract

Objectives: This study investigates the effects of social isolation and loneliness on cognitive function, distinguishing between the effects of transitioning into and out of these states.

Methods: This study analyzed data from 6,663 adults aged 65 or older collected over the course of 7 waves (12 years) of the Korean Longitudinal Study of Ageing from 2006 to 2018. A novel asymmetric fixed effects model was utilized to separately estimate the effects of transitions into and out of social isolation or loneliness.

Results: The association of transitions into social isolation due to a lack of informal social contact or loneliness with cognitive function (b = -1.387, $p < 0.001$ and b = -0.601, $p < 0.001$, respectively) was stronger than the association of transitions out of these states (b = 0.345, $p < 0.05$. and b = 0.353, $p < 0.001$, respectively). The magnitude of the negative and positive coefficients was statistically different (F statistic = 45.29, $p < 0.001$ and F statistic = 5.12, $p < 0.05$, respectively). In contrast, no such asymmetric effects were observed for social isolation due to a lack of formal activity (F statistic = 0.06, p = 0.800).

Discussion: The detrimental effects of transitioning into social isolation due to a lack of informal social contact (but not formal activity) or loneliness on cognitive function outweighs the beneficial effects of transitioning out of these states. Preventing the onset of social disconnection should be prioritized as an intervention to improve the cognitive function of older adults.

Keywords

Social engagement; Cognition; Gender; Asymmetric fixed effects

Introduction

Recent years have seen government institutions and health providers drawing attention to the rising incidence of social isolation and loneliness, labeling it the ‘epidemic of loneliness’ (Jeste et al., 2020). The existing literature links social isolation and loneliness to a spectrum of physical health behaviors and outcomes, ranging from smoking and alcohol consumption to the adoption of healthy practices like regular exercise and a balanced diet, as well as health outcomes including cardiovascular diseases and inflammation (Leigh-Hunt et al., 2017). Emerging evidence also highlights the potential adverse effects of social disconnection on cognitive function (Evans et al., 2019; J. Kim & Kwon, 2023).

Previous research has often adopted a static view of social isolation, characterizing it as a fixed state with diminished or absent social connectedness, overlooking the fluid nature of an individual’s social ties and structures (Bidart & Lavenu, 2005). Disengaging from pre-existing social connections and forming new ones uniquely shapes an individual’s experiences, influenced by the underlying reasons for such changes, the nature of social bonds that are either dissolved or established, and the evolving dynamics within their social relationships (Wrzus et al., 2013). This complexity underscores that each transition may engage different psychological and neurobiological pathways that contribute to cognitive outcomes.

Recent advancements in utilizing longitudinal designs have enhanced our understanding of the causal impact of social disconnection on cognitive function. Fixed effects models effectively address potential issues of both observed and unobserved heterogeneity that confound the relationship between social disconnection and cognitive function (Wooldridge, 2010). However, traditional fixed effects models present methodological limitations (Allison, 2019): they implicitly assume that the effects of social disconnection are symmetrical, implying that the negative effects of transitioning into social disconnection and the positive effects of transitioning out of it are equal in magnitude.

To address these conceptual and methodological limitations, we employ asymmetric fixed effects models to examine the relationship between transitioning into and out of social isolation and loneliness and cognitive function. This asymmetrical approach decomposes main effects into positive and negative changes, allowing for a distinct conceptualization and interpretation of these dynamics. In this paper, we specifically explore how asymmetry in the relationship may manifest differently across types of social isolation, such as formal activity participation and informal social contact. Furthermore, we investigate gender as a potential moderator in this asymmetrical relationship, exploring its role on the relationships between social isolation, loneliness, and cognitive function.

Background

Social isolation, loneliness, and cognitive function

The cognitive function of older adults refers to their mental abilities, including memory, attention, problem-solving, language skills, and decision-making capabilities (Glymour & Manly, 2008). These cognitive processes are essential for performing daily and instrumental activities (Toth et al., 2022), responding to potential hazards in their surroundings (Lei et al., 2022), and managing chronic diseases while adhering to complex medical instructions (Alosco et al., 2012). Therefore, maintaining adequate cognitive function allows older adults to uphold their independence and effectively navigate their daily lives.

Cognitive Reserve Theory posits that engaging in socially and intellectually stimulating activities builds a ‘cognitive reserve’ in the brain, serving as a protective buffer against age-related cognitive decline. This concept is fundamental to understanding how individuals can maintain cognitive function despite the neuropathological changes that occur with aging. The theory suggests that the cognitive reserve is shaped by various social factors, including education, occupation (Stern, 2002), and social engagement (Evans et al., 2018, 2019). Expanding on this idea, Cognitive Enrichment Theory emphasizes that certain activities do more than just mitigate inherent age-related cognitive decline; they actively boost cognitive functioning. According to this theory, intellectual, physical, and social pursuits can directly enhance cognitive abilities (Hertzog et al., 2008), suggesting that cognitive decline is not an inevitable consequence of aging but can be actively countered through engagement in enriching activities. Taken together, these theories underscore the significant role social environments play in shaping cognitive function.

Social isolation refers to a state characterized by limited social connections or interactions, which can arise from factors such as living alone, having few social networks, or reduced social engagement. On the other hand, loneliness is a subjective feeling of being socially isolated or lacking companionship, irrespective of the actual number of social interactions. The mechanisms through which social isolation and loneliness affect cognitive function are complex and multifaceted. First, social isolation and loneliness are detrimental because they restrict social interactions and engagements, which are crucial for protecting cognitive function. Lack of regular social engagement limits opportunities for mental stimulation in older adults, diminishes cognitive activity, and hinders the development of neural connections in the brain, ultimately compromising the maintenance of cognitive reserve (Weaver & Jaeggi, 2021). Second, social isolation and loneliness are associated with increased levels of stress, depression, and anxiety (Mann et al., 2022). Chronic stress and negative emotions can lead to physiological changes in the brain, including inflammation and the release of stress hormones, thus contributing to cognitive decline (Scott et al., 2015). Third, social isolation and loneliness can impact lifestyle factors that influence cognitive health. Older adults experiencing social isolation or loneliness are more likely to have sedentary lifestyles, unhealthy dietary patterns, and poor sleep quality (Azizi-Zeinalhajlou et al., 2022; Delerue Matos et al., 2021), all of which can negatively affect cognitive function.

Asymmetric effects of social isolation and loneliness

Given the patterns in cognitive decline and the mechanisms by which social isolation and loneliness may affect cognitive function as outlined in prior studies, it is reasonable to speculate that the adverse impacts of transitioning into social isolation or loneliness could outweigh the beneficial impacts of transitioning out of these states. The cognitive decline experienced during the period of social isolation or loneliness may be difficult to fully reverse or compensate for, even after reestablishing social connections. Social isolation or loneliness can lead to structural and functional changes in the brain, such as reduced brain volume, altered neural connectivity, and increased inflammation (Gonzales et al., 2022). Once these damages have occurred, it may require significant time and targeted interventions to reverse or compensate for the damage that has occurred (Kline & Mega, 2020). In addition, the combination of age-related changes, reduced neuroplasticity, and co-occurring health conditions may further complicate the process of recovering cognitive decline among older adults when overcoming social isolation or loneliness (Pettigrew & Soldan, 2019).

Furthermore, the potential asymmetric effects of transitions into and out of social isolation or loneliness may relate to the specific mechanisms through which social isolation and loneliness affect cognitive function. Reestablishing social connections and rebuilding relationships after experiencing social isolation or loneliness can be challenging. It often requires time to rebuild a supportive social network and engage in meaningful interactions that facilitate cognitive stimulation (Ablitt et al., 2009). A study suggests that the extent to which a social interaction enhances an individual's cognitive function depends on the context of the interaction, such as the nature of the relationship between the two individuals involved (Ybarra et al., 2007). Moreover, the cognitive model of depression posits that negative experiences and emotions trigger negative schemas; once these schemas are activated, deactivating them becomes increasingly challenging (Haaga et al., 1991). From a behavioral standpoint, social isolation or loneliness can lead to risky behaviors, such as alcohol consumption, while improvements in social relationships do not necessarily result in the cessation of these behaviors (Rosenquist et al., 2010). These distinct mechanisms imply that the negative impact of transitioning into social isolation or isolation can be more pronounced than the positive impact of transitioning out of these states.

The implicit assumption of symmetric effects of social isolation or loneliness stems largely from the inherent limitations of regression analyses employed in prior studies (Rosenberg et al., 2017; York & Light, 2017). The estimated coefficient of social isolation and loneliness on cognitive function is interpreted as the extent of cognitive function changes associated with changes in the states of social isolation and loneliness, regardless of the direction of those changes (Firebaugh et al., 2013). Consequently, this implicit assumption of symmetric effects implies that the impact of transitioning into social isolation or loneliness is considered equal in magnitude to the impact of transitioning out of social isolation or loneliness. This approach fails to consider the possibility of asymmetric effects of social isolation and loneliness on cognitive function (Allison, 2019). In Supplementary Figure 1 (Supplementary Material), we discuss how distinct dynamics might be misrepresented as identical under a symmetrical effects approach.

An asymmetric effects model overcomes this limitation by decomposing the effects into positive and negative changes, allowing for separate interpretations of these changes. Given its strength in detecting potential asymmetries, an increasing number of research is adopting this methodology to explore the asymmetric impacts of phenomena such as bodyweight change (Kronschnabl et al., 2021), spousal caregiving (Uccheddu et al., 2019), physical activity (Baumbach et al., 2023), employment (H. Park et al., 2024). Similarly, this asymmetric approach can be applied to scenarios where an increase in an independent variable does not merely reflect the inverse of its decrease, exemplified by transitions into and out of social isolation or loneliness.

Divergent effects of different forms of social isolation and loneliness

Social isolation is frequently assessed through the dimensions of informal social contact and formal activity, although the specific terminology used to describe these distinct aspects of social relationships may differ significantly across studies (Evans et al., 2019; Kelly et al., 2017). Informal social contact typically refers to the scope or frequency of interactions within an individual's personal network, such as those with friends and acquaintances, while formal activity pertains to engagement in community and institutional contexts, facilitating social interactions in a more organized setting. Due to the varied nature of social interactions in these differing contexts, the impact of social isolation can also diverge, contingent on the specific type of social isolation an individual is transitioning into or out of (J. Kim & Park, 2023a).

Transitioning into a state devoid of both informal social contact and formal activity can adversely affect cognitive function. Social isolation, resulting from an absence of informal social interactions and participation in formal activities, can abruptly interrupt cognitive stimulation, trigger stress and negative emotions, and increase maladaptive health behaviors. However, the effects of reestablishing these relationships (i.e., transitions out of social isolation) might differ, especially regarding the type of cognitive stimulation that various social interactions provide. Engaging in formal activities often requires reengagement in tasks that demand cognitive effort, problem-solving, and learning (Lee & Kim, 2016). In contrast, social interactions in informal settings may not present the same level of cognitive demands or challenges, as they typically involve casual conversations, sharing experiences, or leisure activities that are less cognitively demanding. Moreover, engaging in formal activities provides opportunities for skill development, learning new tasks, and intellectual growth (Grotz et al., 2018), which have more direct positive effects on cognitive function, while informal social contact may not offer substantial opportunities for skill development or acquisition of new knowledge.

Formal activities often involve interactions with a diverse range of individuals, including colleagues, peers, or participants in programs, allowing for exposure to different perspectives and ideas (Sharifian et al., 2019). These interactions can foster intellectual discussions and knowledge exchange, leading to greater cognitive stimulation. In contrast, informal social contact tends to be more limited in scope and may involve a narrower range of social connections, potentially resulting in less diverse cognitive inputs. Furthermore, the context in which social interactions occur also influences their impact on cognitive function. Formal activities often take place in environments designed to promote cognitive engagement, such as workplaces, educational settings, or organized programs (Fratiglioni et al., 2004). These environments are more likely to provide structured opportunities for intellectual discussions, problem-solving, and cognitive challenges. On the other hand, informal social interactions may occur in less cognitively demanding settings, such as social gatherings or casual meetings, where cognitive stimulation may be less prominent (Kelly et al., 2017).

Similar to informal social interactions, transitioning into loneliness could adversely affect cognitive function through distress and negative emotions. However, there is scant evidence to suggest that alleviating these negative states or experiencing positive emotions, such as a sense of belonging, offers equivalent cognitive benefits. Moreover, since transitioning out of loneliness does not necessarily involve cognitive stimulation, such as learning and problem-solving activities, its impact may be similar to that of informal social contact, resulting in a less pronounced effect on cognitive function.

We therefore propose that the sources of social isolation—the lack of formal activities and the lack of informal social interactions—and loneliness affect cognitive functioning differently, which led us to analyze them as separate concepts in our study.

Gender heterogeneity

The well-documented gender differences in the prevalence of social isolation and loneliness, and patterns in cognitive decline suggest that the relationship between social isolation, loneliness, and cognitive function may vary between men and women. Men and women tend to have different socialization patterns and social networks in old age (Harling et al., 2020). Older women are more likely to live alone and experience higher levels of loneliness than older men, influenced by factors such as longer life expectancy, higher rates of widowhood, and differences in marital patterns (J. Kim & Park, 2023b). Previous studies have also found that older women generally experience a slower rate of cognitive decline compared to older men (McCarrey et al., 2016). In addition, men and women may employ different coping mechanisms when faced with social isolation or loneliness. Older women are more inclined to seek social support and engage in social coping strategies, while older men rely more on individual coping mechanisms or avoid seeking help due to societal expectations around masculinity and self-sufficiency (Yoon et al., 2022). Despite these findings, limited evidence exists regarding gender differences in the association between social isolation, loneliness, and cognitive function (Ren et al., 2023).

The present study

This study utilizes seven waves of data from the Korean Longitudinal Study of Ageing (KLoSA), spanning a period of 12 years, to examine the relationship between social isolation, loneliness, and cognitive function. This study adopts asymmetric fixed effects models, which decompose the independent variable into positive and negative components. This approach enables the separate estimation of the effects of transitions into and out of social isolation and loneliness. In addition, building upon the theoretical discussions regarding distinct nature and context of informal social contact and formal activity as sources of social isolation, this study examines the potential differential asymmetric effects of social isolation on cognitive function. Furthermore, the analyses are stratified by gender to investigate whether the asymmetric effects of social isolation and loneliness vary based on gender.

Methods

Data

The data used in this study were derived from the Korean Longitudinal Study of Ageing (KLoSA), a nationally representative longitudinal study that focuses on adults aged 45 and above residing in 15 administrative areas in Korea. Since 2006, this survey has been conducted biennially using the Computer-Assisted Personal Interviewing method to collect respondents' information across various domains, including family relationships, socioeconomic status, social life, mental health, physical health, health care utilization, employment, and financial characteristics among older adults. The sampling frame for the KLoSA was constructed based on enumeration districts obtained from the Population and Housing Census of Korea Statistics. Participants were selected through a multi-stage stratified sampling process, considering their housing type (apartment or regular housing) and geographical location (urban or rural). For this study, longitudinal data spanning a period of 12 years, from 2006 (Wave 1) to 2018 (Wave 7), were utilized. All participants provided informed consent, and the data were anonymized before being uploaded to a publicly accessible database. The study received exemption from ethical approval as it relied on the secondary analysis of publicly available data (KUIRB-2020-0194-02).

Out of a total of 29,206 observations from seven waves, focusing on individuals aged 65 years or older, 656 observations with missing values on key independent variables (2.2%) were excluded. An additional 1,193 observations were dropped due to missing values on cognitive function (5.0%), and 571 observations were dropped due to missing values on control variables (2.5%). As a result, a total of 26,384 observations were used for analysis, representing 3,562 participants in Wave 1, 3,698 in Wave 2, 3,627 in Wave 3, 3,733 in Wave 4, 3,825 in Wave 5, 3,982 in Wave 6, and 3,957 in Wave 7. The final total of participants with valid data points in any of the waves was 6,663 (3,776 women and 2,887 men). This number exceeds the number of observations in each individual wave due to various factors, such as attrition, missing data, and the differing timings of individuals reaching the age of 65. Specifically, we recentered the data to align with the first year each participant became eligible for inclusion in our analysis. This approach was essential due to the varying ages at which individuals entered our study, especially since our focus was on participants aged 65 and older. Consequently, those initially under 65 were included in the sample as they reached this age threshold during the study period, leading to the gradual addition of samples in each wave. In some waves, the number of observations was lower than in previous waves, owing to increased rates of attrition and/or missing data.

Measures

Dependent variable

Cognitive function was evaluated using the K-MMSE, a well-validated measure as demonstrated in prior research (T. H. Kim et al., 2010; G. Park & Kim, 2022). The K-MMSE is a comprehensive assessment tool that measures various aspects of cognitive function, including memory recall, attention, and visual construction. Scores on the K-MMSE range from 0 to 30, with higher scores indicating better cognitive function.

Independent variable

To measure social isolation, we considered two commonly used sources of social isolation from prior research (Evans et al., 2019; Kelly et al., 2017): informal social contact and formal activity. Informal social contact, also referred to as a social network in prior research, is measured through various methods, such as counting the number of individuals within a social network, evaluating the frequency of interactions with social contacts, considering marital status, or examining other indicators like satisfaction with social relationships. In our study, informal social contact was gauged by inquiring about participants' frequency of meetings with friends, relatives, acquaintances, and neighbors living nearby. This method is consistent with the approaches adopted in several studies that have evaluated social networks (Béland et al., 2005; Shankar et al., 2013). We created a dichotomous variable for social isolation (i.e., a lack of frequent informal social contact) if they reported meeting "once or twice a year," "rarely in a year," or "no close contact" (vs. "more than 4 times a week," "once a week," "2-3 times a week," "once a month," "twice a month," "3-4 times a year," or "5-6 times a year").

Formal activity, also referred to as social activity in prior research, is measured by participation in social and community activities. This includes attending clubs, religious and political organizations, leisure activities, neighborhood associations, and gatherings with friends (Béland et al., 2005; Bourassa et al., 2017). Our assessment of formal activity similarly covers participation in a variety of organizations and activities: religious gatherings, friendships, leisure/sports, reunions, volunteering, politics, and others. We created a measure of social isolation (i.e., lack of formal activity) by assigning a value of 1 if the participant reported no regular engagement in any formal organization at the time of the survey, and 0 otherwise.

To assess participants' sense of loneliness, they were asked to indicate the extent to which they felt lonely over the past week, ranging from rarely or never (less than a day), occasionally (1-2 days), often (3-4 days), to always (5-7 days). We created a dichotomous variable for loneliness, classifying respondents as lonely if they reported feeling lonely at least occasionally (1-2 days a week or more).

Control variable

The study added a comprehensive set of control variables. Time-constant covariates included gender, educational attainment (elementary or lower, middle school, high school, and college or higher), and the number of children. Time-varying covariates included age, age squared, household size, household income (divided into quartiles), homeownership (based on whether the respondent lived in owneroccupied or privately rented housing), economic activity (determined by whether the respondent engaged in any kind of paid employment), region of residence (large city, small city, and rural area), the number of chronic diseases (measured by summing ten doctor-diagnosed chronic conditions, such as hypertension, diabetes mellitus, cancer, chronic lung disease, liver disease, heart disease, cerebrovascular disease, psychological disease, arthritis or rheumatoid arthritis, and prostatic disease), and having limitations in activities of daily living (ADLs) (determined by whether the respondent reported needing assistance with at least one of the following seven activities: dressing oneself, washing one's face, bathing oneself, eating, going out of the room, using a toilet, and regulating urine and bowel movements).

Statistical analysis

We employed asymmetric fixed effects (FE) models to examine the effect of transitioning into and out of social isolation and loneliness on cognitive function. In implementing asymmetric FE models, we first decomposed the independent variable into positive and negative components:

$$LON_{it}^{+} = LON_{it} - LON_{it-1} \text{ if } (LON_{it} - LON_{it-1}) > 0\text{, otherwise } 0$$

$$LON_{it}^{-} = -(LON_{it} - LON_{it-1}) \text{ if } (LON_{it} - LON_{it-1}) < 0\text{, otherwise } 0$$

LON_{it}^{+} represents transitions into loneliness and LON_{it}^{-} represents transitions out of loneliness. For $t = 1$, both LON_{it}^{+} and LON_{it}^{-} are set to 0 because there are no preceding wave observations. The same operational approach applied to the two social isolation variables in order to create this variable. The following asymmetric first-difference model for multiperiod data can be estimated using generalized least squares (Allison, 2019):

$$y_{it} - y_{it-1} = (\alpha_t - \alpha_{t-1}) + \beta_1^{+} SI\_informal_{it}^{+} + \beta_1^{-} SI\_informal_{it}^{-} + \beta_2^{+} SI\_formal_{it}^{+} + \beta_2^{-} SI\_formal_{it}^{-} + \beta_3^{+} LON_{it}^{+} + \beta_3^{-} LON_{it}^{-} + (\mathbf{Z}_{it} - \mathbf{Z}_{it-1})\delta + (\varepsilon_{it} - \varepsilon_{it-1})$$

In the equation, $\boldsymbol{Z}_{it}$ represents a vector of time-varying covariates, while time-constant covariates are omitted because they are differenced out. Within the asymmetric FE framework, the coefficient β^{+} represents the effects of transitioning into social isolation or loneliness, while β^{-} represents the effects of transitioning out of social isolation or loneliness. To examine the equality of these effects, we conducted a Wald test for each model comparing β^{+} and β^{-}. We then performed gender-stratified analyses to explore potential gender differences in the asymmetric effects of social isolation and loneliness. To statistically test for gender differences, we estimated separate models for each gender and used a Wald test.

To investigate the impact of attrition-related selection bias on the observed relationship between social isolation, loneliness, and cognitive function, we conducted a sensitivity analysis utilizing inverse probability weighting (IPW). We calculated the predicted probabilities of each individual's continuation in the study (i.e., remaining alive and not being lost to follow-up). Using these probabilities, we then computed analytical weights that are inversely proportional to the chances of survival and ongoing participation in the study. This analysis aimed to account for potential bias arising from attrition by adjusting the estimated probabilities of attrition. Our findings, presented in Supplementary Table 1, demonstrate the robustness of the results when employing IPW to address attrition bias.

Results

Table 1 displays the characteristics of the sample, consisting of 6,663 participants from Wave 1, stratified by gender. Approximately 57% of the respondents were female, with a mean age of 67.17 (*SD* = 8.64). Around 25% of the participants had completed high school education or higher. The mean cognitive function score was 24.29, with a standard deviation of 5.76. About 14%, 32%, and 32% of the participants experienced social isolation due to a lack of informal social contact, social isolation due to a lack of formal activity, and loneliness, respectively. Notable gender differences were observed in the key variables. Compared to women, men exhibited higher cognitive function scores (23.01 vs. 25.97) and were less likely to experience social isolation due to a lack of formal activity (35% vs. 29%) and loneliness (37% vs. 24%). Supplementary Table 2 illustrates the distribution of changes in social isolation and loneliness experiences across survey waves. Among the variables examined, loneliness exhibited the most significant variation over time, followed by social isolation due to formal activity and social isolation due to informal social contact.

Table 2 presents the estimated associations between social isolation, loneliness, and cognitive function. Here, we present the results of pooled ordinary least squares (OLS), standard FE, and asymmetric FE models for comparison. Columns 1, 2, and 3 show the results for the pooled OLS, standard FE, and asymmetric FE models, respectively. The pooled OLS models in Column 1 reveal a significant negative association between social isolation, loneliness, and cognitive function. In Column 2, after accounting for unobserved individual heterogeneity, the associations are considerably attenuated (43% for social isolation (informal social contact), 62% for social isolation (formal activity), and 64% for loneliness). This finding suggests that a portion of the observed association between social isolation, loneliness, and cognitive function is confounded by unobserved heterogeneity at the individual level. However, even after controlling for unobserved individual heterogeneity, the association remains statistically significant (*b* = -0.939 for social isolation (informal social contact), *b* = -0.614 for social isolation (formal activity), and *b* = -0.514 for loneliness). In a sensitivity analysis, we found that the results from models that exclude individuals with suspected dementia are very similar to those from the original analysis in this study.

To relax the assumption of symmetric effects of social isolation and loneliness, we employed asymmetric FE models (Column 3). The results from Column 3 suggest that social isolation due to a lack of informal social contact and loneliness exhibit asymmetric effects on cognitive function. Transitions into social isolation (informal social contact) is associated with a decrease in cognitive function (*b* = -

1.387, $p < 0.001$), while transitions out of social isolation (informal social contact) show a significant positive association with cognitive function ($b = 0.345$, $p < 0.05$). Furthermore, both transitioning into and out of loneliness are associated with cognitive function, but the negative association of transitions into loneliness ($b = -0.601$, $p < 0.001$) is stronger than the positive association of transitions out of loneliness ($b = 0.353$, $p < 0.001$). These asymmetric patterns for social isolation (informal social contact) and loneliness were statistically significant (F statistic = 45.29, $p < 0.001$ and F statistic = 5.12, $p < 0.05$, respectively). These findings suggest that assuming symmetry of effects can mask the stronger impact of transitioning into social isolation (informal social contact) and loneliness. However, no such asymmetric effects were found for social isolation due to a lack of formal activity, as the magnitude coefficients for transitioning into and out of social isolation (formal activity) did not differ significantly ($b = -0.601$, $p < 0.001$ vs. $b = 0.569$, $p < 0.001$, F statistic = 0.06, $p = 0.800$).

Table 3 presents asymmetric FE estimates of the associations between social isolation, loneliness, and cognitive function, stratified by gender (Column 1 for women and Column 2 for men). The gender-stratified analyses did not reveal any statistically significant gender differences in the associations between social isolation, loneliness, and cognitive function. In Column 1, for men, the results indicate asymmetric effects of social isolation due to a lack of informal social contact and loneliness (F statistic = 28.46, $p < 0.001$ and F statistic = 5.20, $p < 0.05$, respectively). Transitioning into social isolation (informal social contact) or loneliness is associated with a decrease in cognitive function ($b = -1.320$, $p < 0.001$ and $b = -0.671$, $p < 0.001$, respectively). In contrast, transitioning out of social isolation (informal social contact) shows no association with cognitive function, while transitioning out of loneliness shows weaker associations ($b = 0.313$, $p < 0.05$). On the other hand, the associations for transitions into and out of social isolation due to a lack of formal activity do not differ significantly in magnitude ($b = -0.629$, $p < 0.001$ vs. $b = 0.560$, $p < 0.001$, F statistic = 0.14, $p = 0.703$). The overall patterns in asymmetric effects are largely similar for women, with one exception: there is no statistically significant asymmetric effects of loneliness on cognitive function (*F* statistic = 0.88, *p* = 0.348) (Column 2).

Discussion

Our study explores the relationship between social isolation, loneliness, and cognitive function, paying particular attention to the asymmetric effects of transitions into and out of social isolation or loneliness. The results of asymmetric FE models provided novel insights by demonstrating a stronger association with transitioning into social isolation due to a lack of informal social contact or loneliness than with transitioning out of these states. The observed asymmetric effects—namely, the diminished impact of transitioning out of social isolation or loneliness—can be attributed to several factors. The biological dimensions of cognitive decline make its reversal in older adults challenging, given the presence of factors such as reduced brain volume, increased inflammation, decreased neuroplasticity, and age-related health complications (Gonzales et al., 2022; Kline & Mega, 2020). Furthermore, the complexities involved in rebuilding relationships and the persistent nature of negative emotional and behavioral patterns suggest that the benefits of re-establishing social connections or overcoming loneliness may not be as immediate or substantial as the detrimental impacts of social disconnection and loneliness (Ablitt et al., 2009; Haaga et al., 1991; Rosenquist et al., 2010; Ybarra et al., 2007).

This study finds no asymmetric effects when transitioning into and out of social isolation due to a lack of formal activity. Specifically, our results suggest that engaging in formal activities could indeed foster cognitive "regeneration." Cognitive Reserve Theory has traditionally posited that intellectual and social stimulation acts primarily as a protective buffer rather than directly enhancing cognitive function (Stern, 2002). However, our findings offer empirical support to the Cognitive Enrichment Theory, which argues that participation in intellectual, physical, and social activities can directly enhance an individual's cognitive abilities (Hertzog et al., 2008). Furthermore, the results of this study indicate that the benefits of transitioning out of social isolation depend significantly on the type and quality of social interactions. For instance, A study have shown that social interactions involving cooperative goals or intellectual tasks are more conducive to improving cognitive function (Ybarra et al., 2010). Our findings extend this view, suggesting that formal activities, which entail structured engagement with others, can facilitate intellectual and social stimulation, thereby potentially improving cognitive function.

In addition, our study did not find statistically significant gender differences. Aligning with our results, a substantial body of research similarly reports no discernible gender differences in the impact of social isolation on cognitive function (Elovainio et al., 2022; Evans et al., 2019; Montoliu et al., 2019). Several factors could explain the lack of observed gender heterogeneity. According to Social Role Theory, women often have a greater emotional investment in relationships than men (Cross & Madson, 1997), which could heighten their sensitivity to the adverse emotions stemming from social isolation. Conversely, men may be more adversely affected in terms of cognitive function by social isolation due to a tendency towards maladaptive coping strategies (Cornwell, 2011). These divergent psychological and behavioral responses could neutralize potential gender differences in the effects of social isolation. Additionally, the concept of role convergence among older adults (Lewis & Yoneda, 2021) suggests that with aging, women and men exhibit more similar biological, psychological, and behavioral characteristics, potentially leading to uniform responses to social isolation and loneliness across genders.

This study has several limitations that should be acknowledged. First, this study was unable to examine the long-term consequences of transitioning into and out of social isolation or loneliness due to the focus of asymmetric FE models on immediate effects. Future research could explore whether the asymmetric effects of social isolation due to a lack of informal social contact or loneliness diminish over time as the positive effects of transitions out of social isolation or loneliness become apparent in the long term. Second, although we employed FE models to control for time-constant confounders, both observed and unobserved, it is important to acknowledge that the presence of time-varying confounders can still introduce bias to the FE estimates (Wooldridge, 2010). Despite our efforts to account for time-varying covariates in the analysis, this approach is not exhaustive in addressing the issue since it does not control for unobserved time-varying confounders. Third, while our study assesses two representative dimensions of social isolation, it is limited by employing single-item measures for each dimension. For example, the measurement for informal social contact is based solely on the frequency of interactions across various relationships. Future research should adopt a more comprehensive measurement approach that encompasses multiple dimensions, including the range, intensity, and nature of these social interactions.

Based on the specific findings of the study, there are policy implications that can be derived. Given stronger impacts of transitions into rather than out of social isolation due to informal social contact or loneliness, policymakers should prioritize the development and implementation of preventive measures that aim to reduce the risk of social isolation and loneliness among older adults. This can include targeted public awareness campaigns, community-based initiatives, and educational programs that promote the importance of social engagement and provide resources for maintaining social connections (NASEM, 2020). Policies should also emphasize early intervention strategies to identify and support individuals who are at risk of transitioning into social isolation or experiencing loneliness. This can involve proactive screening processes in healthcare settings, community outreach programs, and collaborations with social service organizations to identify and provide timely interventions for older adults who may be at risk (Yan et al., 2022).

Given the significant positive impacts of transitions out of social isolation due to a lack of formal activity, policies should focus on promoting and facilitating opportunities for older adults to engage in formal activities. This can include initiatives such as senior centers, community centers, clubs, and organizations that offer structured activities such as educational programs, fitness classes, arts and crafts workshops, and volunteering opportunities (Gardiner et al., 2018). By encouraging older adults to participate in these activities, policies can facilitate their transitions out of social isolation and promote positive impacts on cognitive function. Policymakers should also work to remove barriers that hinder older adults from accessing formal activity opportunities by improving transportation options, ensuring affordable access to activities, and addressing physical accessibility concerns (Ravensbergen et al., 2022). Creating an environment that is inclusive and accommodating may encourage older adults to engage in formal activities and reap the associated cognitive benefits.

In conclusion, this study enhances our understanding of the relationship between social isolation, loneliness, and cognitive function. The findings of this study reveal that the detrimental effect on cognitive function when transitioning into social isolation is stronger than the beneficial effect observed when transitioning out of it. This asymmetry in the effects of social isolation is evident only in instances attributable to a lack of informal social contact. In contrast, social isolation resulting from a lack of formal activity demonstrates symmetric effects; that is, the detrimental effect of transitioning into social isolation is similar in magnitude as the beneficial effect of transitioning out of it. These patterns were substantially similar for women and men. The results of this study indicate that interventions focused on social integration can be an effective method for improving cognitive function in older adults. Specifically, programs designed to maintain social connections among older adults to prevent cognitive decline could be especially beneficial for promoting healthy aging.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

Data Availability

The KLoSA data are available at https://survey.keis.or.kr/klosa/klosa01.jsp with the permission of the Korea employment Information Service. Analytic methods and materials specific to the current study are available upon request from the corresponding author. The current study was not preregistered with an analysis plan in an independent, institutional registry.

Author Contributions

Jinho Kim and Sungsik Hwang contributed equally to this research.

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Table 1. Summary statistics, KLoSA 2006

Variable	Total Mean /Prop.	*SD*	Min.	Max.	Women Mean /Prop.	Men Mean /Prop.	Gender diff.
Dependent variable							
Cognitive function	24.29	5.76	0.00	30.00	23.01	25.97	*
Independent variable							
Social isolation (informal social contact)	0.14		0.00	1.00	0.15	0.14	
Social isolation (formal activity)	0.32		0.00	1.00	0.35	0.29	*
Loneliness	0.32		0.00	1.00	0.37	0.24	*
Time-constant covariates							
Female	0.57		0.00	1.00	1.00	0.00	*
Elementary or lower	0.61		0.00	1.00	0.75	0.42	*
Middle school	0.15		0.00	1.00	0.13	0.17	*
High school	0.18		0.00	1.00	0.10	0.28	*
College or higher	0.07		0.00	1.00	0.02	0.13	*
Number of children	3.44	1.58	0.00	10.00	3.56	3.28	*
Time-varying covariates							
Age	67.17	8.64	53.00	98.00	67.59	66.61	*
Married	0.73		0.00	1.00	0.59	0.92	*
Household size	2.75	1.35	1.00	11.00	2.70	2.81	*
Logged household income	6.12	2.31	0.00	10.42	5.99	6.28	*
Homeownership	0.79		0.00	1.00	0.77	0.81	*
Economic activity	0.29		0.00	1.00	0.17	0.45	*
Large city	0.42		0.00	1.00	0.43	0.42	
Small city	0.30		0.00	1.00	0.30	0.30	
Rural	0.28		0.00	1.00	0.28	0.28	
Number of chronic diseases	0.94	1.01	0.00	7.00	1.02	0.83	*
Having limitations in ADLs	0.06		0.00	1.00	0.06	0.05	
Observations	6,663				3,776	2,887	

Note. ADLs = Activities of Daily Living. Summary statistics are based on 2006 data. Chi-squared tests for categorical variables and *t* tests for continuous variables were performed.

* Differences are statistically significant, $p < 0.05$.

Table 2. Effects of social isolation and loneliness on cognitive function

Dependent variable	(1) Cognitive function	(2) Cognitive function	(3) Cognitive function
Sample	Total	Total	Total
Estimation model	Pooled OLS	Standard FE	Asymmetric FE
Time-constant covariates	Yes	No	No
Time-varying covariates	Yes	Yes	Yes
N(Observations)	26,384	26,384	26,384
Social isolation (informal social contact)	-1.639***	-0.939***	
	(0.117)	(0.120)	
Transitions into social isolation (informal social contact) (A)			-1.387***
			(0.143)
Transitions out of social isolation (informal social contact) (B)			0.345*
			(0.140)
Social isolation (formal activity)	-1.599***	-0.614***	
	(0.077)	(0.085)	
Transitions into social isolation (formal activity) (C)			-0.601***
			(0.105)
Transitions out of social isolation (formal activity) (D)			0.569***
			(0.108)
Loneliness	-1.423***	-0.514***	
	(0.065)	(0.064)	
Transitions into loneliness (E)			-0.601***
			(0.082)
Transitions out of loneliness (F)			0.353***
			(0.087)
p-value for (A) = – (B)			0.0000***
p-value for (C) = – (D)			0.8006
p-value for (E) = – (F)			0.0236*

Note. OLS = Ordinary Least Squares; FE = Fixed Effects; ADLs = Activities of Daily Living. Robust standard errors are shown in parentheses. All models include survey year dummy variables. Time-constant covariates include gender, educational attainment, and number of children. Time-varying covariates include age, marital status, household size, logged household income, homeownership, economic activity, place of residence, number of chronic diseases, and having limitations in ADLs.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 3. Effects of social isolation and loneliness on cognitive function, by gender

Dependent variable	(1) Cognitive function	(2) Cognitive function
Sample	Men	Women
Estimation model	Asymmetric FE	Asymmetric FE
Time-constant covariates	No	No
Time-varying covariates	Yes	Yes
N(Observations)	11,214	15,170
Transitions into social isolation (informal social contact) (A)	-1.320***	-1.408***
	(0.218)	(0.187)
Transitions out of social isolation (informal social contact) (B)	0.108	0.509**
	(0.212)	(0.185)
Transitions into social isolation (formal activity) (C)	-0.629***	-0.570***
	(0.154)	(0.141)
Transitions out of social isolation (formal activity) (D)	0.560***	0.594***
	(0.161)	(0.144)
Transitions into loneliness (E)	-0.671***	-0.533***
	(0.121)	(0.111)
Transitions out of loneliness (F)	0.313*	0.392***
	(0.129)	(0.116)
p-value for (A) = – (B)	0.0000***	0.0000***
p-value for (C) = – (D)	0.7035	0.8878
p-value for (E) = – (F)	0.0227*	0.3481

Note. FE = Fixed Effects; ADLs = Activities of Daily Living. Robust standard errors are shown in parentheses. All models include survey year dummy variables. Time-constant covariates include gender, educational attainment, and number of children. Time-varying covariates include age, marital status, household size, logged household income, homeownership, economic activity, place of residence, number of chronic diseases, and having limitations in ADLs.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$