Preventive Medicine Reports 34 (2023) 102261

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Association between social isolation and subjective cognitive decline in Korean older adult population: A nationwide cross-sectional study in South Korea

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ARTICLE INFO

Keywords:
Older adult
Physical activity
Social isolation
Subjective cognitive decline

ABSTRACT

This study aimed to analyze the association between social isolation (SI) and subjective cognitive decline (SCD) in Koreans aged 65 years or older.

The cross-sectional study of the Korea Community Health Survey (KCHS) was conducted on 72,904 individuals aged 65 years or older. SI was defined using five indicator, and an increasing number of SI indicators signifies a higher level of SI. SCD was defined as self-observed impairment of more frequent or worsening memory loss or confusion within the previous 12 months. The cognitive function questionnaire included questions regarding SCD. Chi-square test and weighted logistic regression analysis were used to analyze the association between SI and SCD.

SI group had higher odds of SCD experience rate than the non-SI (AOR:1.15, 95 % CI: 1.08–1.22). Subgroup analysis showed that when SI occurred in the non-Moderate or Vigorous Physical Exercise (MVPE) group, SI group was more likely to experience SCD compared with the non-SI (AOR: 1.17, 95 % CI: 1.10–1.25). However, when SI occurred in the MVPE group, there were not find out the association between SI and SCD.

The results of this study showed that the SI group had a higher rate of SCD than the non-SI group. Particularly, a strong association was observed in the non-MVPE. Therefore, even if SI occurs, SCD can be prevented by educating individuals regarding the importance of participating in MVPE and depression.

1. Introduction

According to the "Future Population Estimation" released by the National Statistical Office, Korea's individuals aged 65 or older composes 17.5 % of the population in 2022, exceeding 14 % of the UN-defined "aging society" standard. By 2025, 20.6 % of the population is predicted to become an "ultra-aged society" (KOSTAT, 2021). In addition, Korea's aging rate is 4.4 % per year, 1.7 times the Organization for Economic Cooperation and Development (OECD) average of 2.6 %, ranking first among OECD countries; if the current aging rate continues, Korea's aging population is expected to be third among OECD countries by 2036 (Korea Economic Research Institute, 2021). The rapid increase in the older adult population in Korea has resulted in various social problems, such as economic problems, suicide, and medical expenses (Eun, 2008; Kim and Yoon, 2013; Yi and Hwang, 2015). Social isolation (SI) has recently emerged as a major problem in South Korea (Park et al., 2020).

SI is defined as a reduction in the sense of social belonging due to a lack of social networks and meetings with other individuals, which are essential elements for maintaining life (Weiss, 1973; Ciolfi and Jimenez, June 2017.). In addition, the SI is considered an important indicator of the extent of social interaction and has been shown to determine an individual's quality of life (KOSTAT, 2020). Globally, SI has continued to increase (OECD, 2017). According to the "Social Survey: Social isolation" report released by the Statistics Korea (KOSTAT, 2020), SI among individuals aged "19–29 years old" was at 18.4 %, while SI

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https://doi.org/10.1016/j.pmedr.2023.102261
Received 17 November 2022; Received in revised form 21 May 2023; Accepted 22 May 2023
Available online 26 May 2023

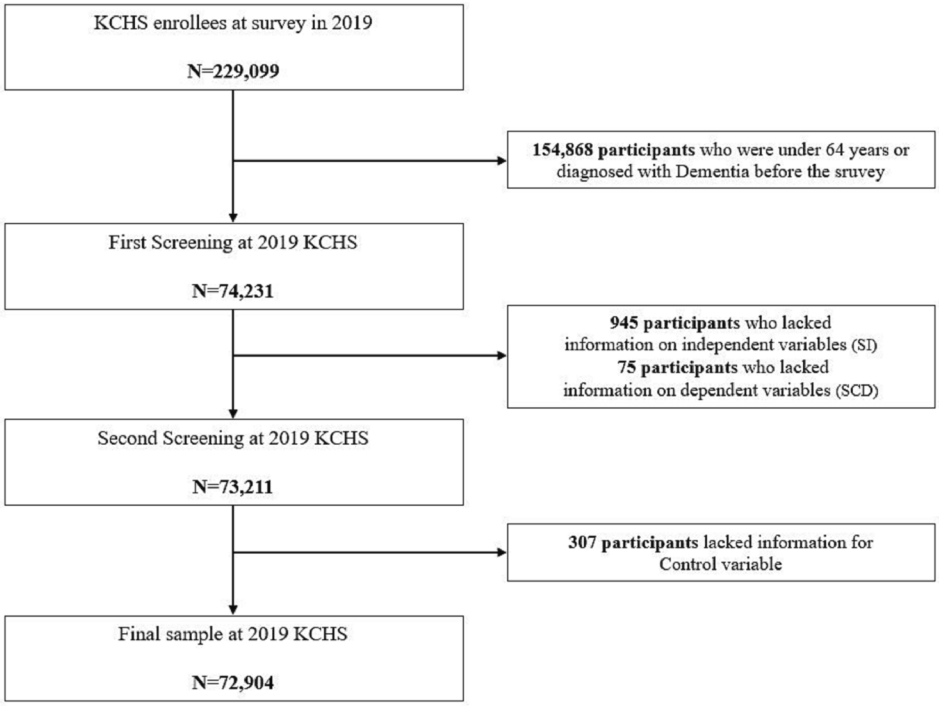

Fig. 1. Flow chart for sample selection.

among individuals aged "60 years or older" was at 36.6 %. Moreover, Korea's SI rate is 24.1 %, which is much higher than the OECD average of 11.4 % (OECD, 2017). The reason for this higher rate of SI is a lower rate of participation in social activities, such as social networks and physical activities (Katagiri and Kim, 2018). Previous studies (Kim, 2017) on chronic diseases, poverty, economic difficulties, and lonely deaths due to SI have been conducted in Korea. In addition, studies on cognitive decline in the older adults are ongoing both in Korea and abroad (Lara et al., 2019; Kim, 2018).

According to a report by the World Health Organization (WHO), the global population of individuals with dementia will be approximately 55 million in 2021; dementia and SI were selected as the top public health concerns among the older adults (Prince et al., 2015), and this number is expected to increase by more than triple by 2050 (WHO, 2017). According to Elvira's prior study (Lara et al., 2019), when studying SI, a decrease in objective cognitive ability was noted, in which complex cognitive scores, language fluency, and memory ability decreased; this decrease in objective cognitive ability was found to be a risk factor for dementia. A recent study on Subjective Cognitive Decline (SCD) as an initial indicator of dementia and mild cognitive decline (MCI) has been conducted (Jessen et al., 2014; Si et al., 2020). According to the US Centers for Disease Control and Prevention (Taylor et al., 2018), the SCD response rate among the older adults in the United States was 24.2 %. In addition, Lee's prior study (Lee et al., 2020) found that 24.6 % of older adults in Korea experienced SCD.

Concurrently, several previous studies have reported that SCD occurs at varying rates depending on age, exercise status, and presence of depression, and is considered a modifiable risk factor. A previous study conducted in Australia emphasized the importance of high-intensity exercise as a preventive measure against both SCD and MCI (Lautenschlager et al., 2019). Additionally, a previous study in the United States reported a 2.8-fold higher incidence of dementia among individuals with concurrent SCD and depression (Liew, 2019).

Therefore, the importance of preventing SCD has been emphasized because the incidence of dementia associated with SCD is remarkably high (Lee et al., 2020). However, despite previous studies showing that SI causes cognitive disorders (Kim, 2017; Lara et al., 2019) and that dementia in older adults can result from SCD (Jessen et al., 2014; Si et al., 2020), no study has assessed the association between SI and SCD in the Korean older adult population. Finally, this study aimed to investigate the association between SI and SCD in the older adult population. In addition, subgroup analyses within the categorized age groups, moderate or vigorous physical exercise (MVPE), and depression were conducted.

2. Materials and methods

2.1. Data source and study participants

This study used the 2019 Korea Community Health Survey (KCHS) (Korea Centers for Disease Control and Prevention, 2019) surveyed by the Korea Ministry of Health and Welfare KDCA (Korea Disease Control and Prevention Agency). This study is a secondary analysis that used raw data from the KCHS and related pledges to investigate the association between SI and SCD in the older adult population living in Korea.

The KCHS was conducted to establish and evaluate health policies through securing local health statistics according to the implementation of the local government system to understand the health status of local residents. In addition, this statistics will be used as basic data to calculate health statistics at the city, county, and district levels, which are necessary for establishing local healthcare plans, expanding infrastructure, and evaluating the performance of local health projects. The KCHS has been an annual sample survey of 251 public health centers in 16 cities/province since 2008 and data were extracted using a systematic extraction method considering the number of households based on the number of households by type of house in Tong, Ban/ri. In addition, these data were surveyed so that representative samples could be extracted from adults aged 19 years or older among the sample household members. A total of 229,099 individuals participated in the 2019 KCHS.

Among the 229,099 individuals who were registered in the 2019 KCHS, we excluded 154,868 individuals under 64 years or those diagnosed with dementia before the 2019 KCHS, 945 individuals who lacked information on independent variables (SI), 75 individuals who lacked

Table 1
General characteristics of the study population with social isolation at 2019 KCHS.

Variables	Total		SCD				p-value
			No		Yes		
	N	%*	N	%*	N	%*	
Total	72,904	100.0	51,622	70.5	21,282	29.5	
Social isolation							<0.0001
Non-SI	60,074	84.8	43,459	71.9	16,615	28.1	
SI	12,830	15.2	8,163	62.7	4,667	37.3	
No. indicators of SI							<0.0001
0	23,174	31.2	17,502	75.1	5,672	24.9	
1	20,536	31.1	14,934	72.7	5,602	27.3	
2	16,364	22.5	11,023	66.4	5,341	33.6	
3	9,654	11.5	6,261	64.0	3,393	36.0	
4	3,026	3.4	1,826	59.3	1,200	40.7	
5	150	0.3	76	50.4	74	49.6	
Age							<0.0001
65–69	20,249	31.3	15,699	76.5	4,550	23.5	
70–74	18,214	26.1	13,473	73.6	4,741	26.4	
75–79	17,262	22.2	11,837	67.8	5,425	32.2	
≥ 80	17,179	20.4	10,613	60.4	6,566	39.6	
Sex							<0.0001
Male	30,407	44.7	22,602	74.1	7,805	25.9	
Female	42,497	55.3	29,020	67.6	13,477	32.4	
Educational Level							<0.0001
≤ Elementary school	43,690	47.9	29,545	66.5	14,145	33.5	
Middle school	12,472	19.5	9,229	72.6	3,243	27.4	
High school	11,330	20.7	8,620	74.8	2,710	25.2	
≥ College	5,412	11.8	4,228	76.0	1,184	24.0	
Monthly household income, thousand KRW							<0.0001
≤ 100	26,883	27.0	17,934	65.8	8,949	34.2	
100–200	20,386	27.2	14,607	70.2	5,779	29.8	
200–300	10,928	17.4	8,174	73.8	2,754	26.2	
≥ 300	14,707	28.4	10,907	73.2	3,800	26.8	
Residency Region							0.0024
Urban area - large city	14,364	38.6	10,062	69.6	4,302	30.4	
Urban area - small city	11,842	24.4	8,525	71.2	3,317	28.8	
Rural area	46,698	37.0	33,035	71.0	13,663	29.0	
Smoking Status (within lifetime)							<0.0001
Ever	25,825	37.9	18,904	72.9	6,921	27.1	
Never	47,079	62.1	32,718	69.0	14,361	31.0	
Alcohol Status (within lifetime)							0.0818
Ever	47,936	69.4	34,044	70.7	13,892	29.3	
Never	24,968	30.6	17,578	70.0	7,390	30.0	
MVPE							<0.0001
No	65,280	89.1	46,013	70.2	19,267	29.8	
Yes	7,624	10.9	5,609	73.0	2,015	27.0	
Depression							<0.0001
No	67,830	92.5	49,236	72.5	18,594	27.5	
Yes	5,074	7.5	2,386	45.7	2,688	54.3	
Perceived Stress Level							<0.0001
Very	12,022	16.6	7,075	58.3	4,947	41.7	
Less	32,060	45.8	22,814	71.5	9,246	28.5	
Low	28,822	37.5	21,733	74.7	7,089	25.3	
Diabetes Diagnosis							0.0009
No	57,180	77.5	40,655	71.0	16,525	29.0	
Yes	15,724	22.5	10,967	68.9	4,757	31.1	

(*continued on next page*)

Table 1 (*continued*)

Variables	Total		SCD				p-value
			No		Yes		
	N	%*	N	%*	N	%*	
Hypertension Diagnosis							<0.0001
No	32,852	45.6	23,557	71.4	9,295	28.6	
Yes	40,052	54.4	28,065	69.7	11,987	30.3	

Note: **KCHS**: Korea Community Health Survey; **SI**: Social Isolation; **No.**: The number of; **SCD**: Subjective Cognitive Decline; **MVPE**: Moderate or Vigorous Physical Exercise; **%***: Weighted Percentage.

information on dependent variables (SCD), and 307 individuals with missing values for control variables to investigate the association between SI and SCD [Fig. 1].

2.2. Independent variables

In this study, the independent variable was SI. The indicators of SI was defined as "the presence of a spouse," "social network," "single-person household," "participation in social activities," and "job status" by referring to prior studies (Steptoe et al., 2013; Menec et al., 2019). The scores range from 0 to 5, with higher scores indicating greater SI (Steptoe et al., 2013; Menec et al., 2019). Appendix 1 shows the general characteristics of SI [Appendix 1]. The criteria for independent variables for determining SI were defined as "SI group" in the case of "3–5" based on previous studies by Steptoe (Steptoe et al., 2013) and Mence (Menec et al., 2019). In addition, in this study model, as a result of conducting the Hosmer and Lemeshaw tests by setting the SI cut-off to "2–5" and "3–5," defining "3–5" as SI cut-off criteira was found to be more suitable for the model.

Additionally, we propose the SI as continuous variables to test the robustness of the results.

2.3. Dependent variables

The dependent variable in this study was SCD, and the question based on the Behavioral Risk Factor Surveillance System (BRFSS) (Nelson et al., 2001) was, "Have you experienced increasingly frequent or severe mental confusion or memory loss in the last year?" If the response was "Yes," it was defined as SCD, and if the response was "No," it was defined as not SCD.

2.4. Control variables

In this study, predefined data, such as "age," "sex," "education level," "residential area," and "household monthly income," of the community health survey were selected as variables. The age group was classified as "65–69 years old," "70–74 years old," "75–79 years old," and "80 years or older," and sex was classified as "male" and "female." Education level was classified as "elementary school graduates or lower," "middle school graduates," "high school graduates," and "college graduates or higher," and residential areas were classified as "urban area—large city" and "rural area." Household monthly income was classified as "≤100″, "100–200," "200–300," and "≥300.".

As variables for health behavior factors, predefined data, such as "smoking status," "drinking status," " MVPE," "depression," "subjective stress level," "hypertension diagnosis," and "diabetes diagnosis," were selected as variables. Smoking status was classified as "ever" and "never," and drinking status was classified as "ever" and "never." MVPE was classified as "yes" and "no." Depression was assessed using the PHQ-9 score. The group that scored under 9 was classified as "no," and a score over 10 was classified as "yes." Subjective stress levels were classified as "a lot of feeling," "a little feeling," and "almost no feeling." The diagnosis of hypertension and diabetes were classified as "yes" and "no.".

2.5. Analytical approach and statistics

In this study, the general characteristics of the SI and SCD groups were compared using the chi-square test with complex sampling Rao–Scott correction to represent the entire population, as this study was designed to use weighted values. Weighted logistic regression analysis was performed after adjusting for age, sex, education level, monthly household income, residential area, smoking and drinking experience, MVPE, depression experience, subjective stress level, hypertension diagnosis, and diabetes diagnosis. In addition, subgroup analyses within the categorized age groups, MVPE, and depression were conducted.

For all analyses, the criterion for statistical significance was two-tailed $P < 0.05$. All analyses were performed using SAS statistical software package (version 9.4; SAS Institute, Cary, NC, USA).

3. Results

Table 1 presents the general characteristics of the participants. Among the 72,904 participants, the SCD experience rate was 29.5 % (n = 21,282), and the SI experience rate was 15.2 % (n = 12,830). The SCD experience rate was 37.3 % (n = 4,667) in the experienced SI group. Regarding the number of indicators of SI, the "0″ group was 31.2 % (n = 23,174), and among them, the SCD experience rate was 24.9 % (n = 5,672). Concurrently, the "5" groups accounted for 0.3 % (N = 150), of which 49.6 % (n = 74) were in the SCD experience group.

Table 2 shows the results of the logistic regression analysis after correcting for control variables to investigate the association between SI and SCD. In Model 1, Compared to the non-SI group, the SI group had higher odds of the SCD experience rate, which was statistically significant (adjusted odds ratio [AOR]: 1.15, 95 % confidence interval [CI]: 1.08–1.22). In model 2, Compared to the "0″ group, the "5" group showed a higher SCD experience rate (AOR: 2.14, 95 % CI: 1.51–3.03).

Table 3 reports the subgroup analysis stratified by age, MVPE and depression. In terms of MVPE variables, when SI occurred in the non-MVPE group, the SI group had higher odds of the SCD rate compared to the non-SI group (AOR: 1.17 and 95 % CI: 1.10–1.25). However, when SI occurred in the MVPE group, there were not find out the association between SI and SCD (AOR: 0.85 and 95 % CI: 0.67–1.09). among the depression group, compared to the non-SI, SI group was associated with 19 % higher risk of SCD (AOR: 1.19, 95 % CI: 1.05–1.34). also, in the non-depression group, SI group was associated with 14 % higher risk of SCD (AOR: 1.14, 95 % CI: 1.07–1.22).

4. Discussion

This study aimed to analyze the association between SI and SCD in an older adult population using data from the 2019 KCHS. The results are summarized as follows: The SI group had a higher SCD rate than the non-SI group. In addition, when SI occurred in the group with higher MVPE, the rate of SCD was lower than that in the group with lower MVPE. In addition, when SI occurred in the depression group, the SCD rate was higher than that in the non-depression group.

Table 2
Factors associated with subjective cognitive decline in the group of social isolation.

Variables	SCD <Model 1>			SCD <Model 2>		
	Crude OR	Adjusted OR[a]	95% CI	Crude OR	Adjusted OR[a]	95% CI
Social isolation						
No	1.00	1.00		N/A		
Yes	1.52 (1.43–1.61) ***	1.15	(1.08 – 1.22) ***			
No. indicators of SI						
0	N/A			1.00	1.00	
1				1.13 (1.07–1.20) ***	1.06	(0.99 – 1.12)
2				1.53 (1.44–1.62) ***	1.22	(1.14 – 1.30) ***
3				1.69 (1.58–1.81) ***	1.21	(1.12 – 1.31) ***
4				2.07 (1.86–2.30) ***	1.45	(1.29 – 1.62) ***
5				2.97 (2.08–4.23) ***	2.14	(1.51 – 3.03) ***
Age						
65–69	1.00	1.00		1.00	1.00	
70–74	1.17 (1.10–1.24) ***	1.16	(1.09 – 1.24) ***	1.17 (1.10–1.24) ***	1.15	(1.08 – 1.23) ***
75–79	1.55 (1.45–1.65) ***	1.52	(1.42 – 1.63) ***	1.55 (1.45–1.65) ***	1.49	(1.39 – 1.59) ***
≥ 80	2.14 (2.00–2.27) ***	2.13	(1.99 – 2.29) ***	2.14 (2.00–2.27) ***	2.05	(1.91 – 2.20) ***
Sex						
Male	1.00	1.00		1.00	1.00	
Female	1.37 (1.32–1.43) ***	1.33	(1.24 – 1.44) ***	1.37 (1.32–1.43) ***	1.33	(1.24 – 1.44) ***
Educational Level						
≤ Elementary school	1.59 (1.47–1.73) ***	1.23	(1.12 – 1.36) ***	1.59 (1.47–1.73) ***	1.22	(1.11 – 1.33)
Middle school	1.20 (1.09–1.31) **	1.11	(1.00 – 1.23) *	1.20 (1.09–1.31) **	1.11	(1.00 – 1.22)
High school	1.06 (0.97–1.17)	1.03	(0.94 – 1.14)	1.06 (0.97–1.17)	1.03	(0.94 – 1.14)
≥ College	1.00	1.00		1.00	1.00	
Monthly household income, thousand KRW						
≤ 100	1.42 (1.34–1.51) ***	1.03	(0.96 – 1.11)	1.42 (1.34–1.51) ***	0.99	(0.92 – 1.07) ***
100–200	1.16 (1.09–1.24) ***	1.06	(0.99 – 1.14)	1.16 (1.09–1.24) ***	1.06	(0.98 – 1.13) *
200–300	0.97 (0.90–1.05)	0.96	(0.88 – 1.04)	0.97 (0.90–1.05)	0.96	(0.89 – 1.04)
≥ 300	1.00	1.00		1.00	1.00	
Residency Region						
Urban area - large city	1.00	1.00		1.00	1.00	
Urban area - small city	0.92 (0.87–0.99) *	0.92	(0.86 – 0.98) **	0.92 (0.87–0.99) *	0.92	(0.86 – 0.98) **
Rural area	0.93 (0.89–0.98) **	0.87	(0.82 – 0.92) ***	0.93 (0.89–0.98) **	0.88	(0.83 – 0.93) ***
Smoking Status (within lifetime)						
Ever	0.83 (0.79–0.86) ***	1.10	(1.02 – 1.19) *	0.83 (0.79–0.86) ***	1.09	(1.01 – 1.17) *
Never	1.00	1.00		1.00	1.00	
Alcohol Status (within lifetime)						
Ever	0.97 (0.92–1.01)	1.20	(1.14 – 1.26) ***	0.97 (0.92–1.01)	1.20	(1.14 – 1.26) ***
Never	1.00	1.00		1.00	1.00	
MVPE						
No	1.15 (1.06–1.24) **	0.94	(0.87 – 1.01)	1.15 (1.06–1.24) **	0.92	(0.86 – 0.99) *
Yes	1.00	1.00		1.00	1.00	
Depression						
Yes	1.00	1.00		1.00	1.00	
No	3.15 (2.91–3.40) ***	2.44	(2.24 – 2.66) ***	3.15 (2.91–3.40) ***	2.41	(2.22 – 2.62) ***
Perceived Stress Level						
Very	2.11 (1.99–2.25) ***	1.79	(1.67 – 1.91) ***	2.11 (1.99–2.25) ***	1.80	(1.68 – 1.92) ***
Less	1.17 (1.12–1.23) ***	1.23	(1.16 – 1.29) ***	1.17 (1.12–1.23) ***	1.23	(1.17 – 1.30) ***
Low	1.00	1.00		1.00	1.00	
Diabetes Diagnosis						
No	1.00	1.00		1.00	1.00	
Yes	1.11 (1.05–1.17) ***	1.08	(1.03 – 1.15) **	1.11 (1.05–1.17) ***	1.08	(1.03 – 1.14) **

(continued on next page)

Table 2 (*continued*)

Variables	SCD <Model 1>			SCD <Model 2>		
	Crude OR	Adjusted OR[a]	95% CI	Crude OR	Adjusted OR[a]	95% CI
Hypertension Diagnosis			–			
No	1.00	1.00		1.00	1.00	
Yes	1.09 (1.04–1.13) **	0.98	(0.93 – 1.03)	1.09 (1.04–1.13) **	0.98	(0.93 – 1.02)

Note: **SI**: Social Isolation; **SCD**: Subjective Cognitive Decline; **MVPE**: Moderate or Vigorous Physical Exercise; **NO.**: The number of; **OR**: Odds Ratio.
[a] Weighted Odds Ratio.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

According to previous studies (KOSTAT, 2020), the SI of the older adult group in the Korean older adult population was significantly higher than that of other age groups. In addition, high SI in the older adults was found to reduce emotional communication due to retirement and bereavement, resulting in a decrease in cognitive ability compared with other age groups (Wrzus et al., 2013; Casey and Holmes, 1995). In addition, SI was found to be a cause of cognitive decline due to an unhealthy diet and lack of physical activity in the older adults (Steptoe et al., 2004). According to Steptoe (Steptoe et al., 2013), SI in the older adult causes loneliness and depression, further increasing cognitive decline. In addition, Kim's prior study (Kim, 2018) showed that the SI of the older adults not only restricts them from obtaining necessary information but also prevents them from receiving help when they require help, resulting in a negative perception of human relationships, which naturally decreases the level of cognitive function. Therefore, the results of this study showed that the older adults with SI had a higher rate of SCD than the non-SI group, which can be explained by the findings of previous studies.

In addition, the results of one study found that the group with less than MVPE had a relatively higher SCD when SI occurred than the group with MVPE, which was consistent with prior studies. According to a previous study by Schrepft (Schrempft et al., 2019), the SI group had higher levels of mild physical activity, such as sedentary activity, than the non-SI group; however, the MVPE was lower than that of the non-SI group. When the MVPE decreased in the SI group, the SCD was higher than that in the other groups. According to Omura's prior study (Omura et al., 2020), the rate of SCD in the active physical activity group was 8.8 %, whereas the rate of SCD in the non-physical activity group was 15.7 %. In addition, a decrease in MVPE in the older adult group led to a decrease in activities of daily living (ADL), and the rate of dementia was higher than that in the other groups (Burge et al., 2012). However, as in prior studies that analyzed the relationship between physical activity and cognitive ability in the older adults, when the older adults participate in MVPE, the rate of cognitive decline was found to decrease owing to effects, such as improved concentration, muscle development, and psychological stability (Zhang et al., 2019; Blondell et al., 2014). Chen et al. showed that regular MVPE in the older adults reduced SCD and the risk of Alzheimer's disease by 45 % (Wen et al., 2021).

In addition, when SI occurred in the older adult group with depression in this study, the finding that the rate of SCD was higher than that in the non-depressive group was consistent with the results of Zvinak's prior study (Zlatar et al., 2018), which was found to gradually reduce cognitive function by changing the blood flow in the frontal, temporal, and cerebellar regions of the brain due to continuous depression (Dotson et al., 2009; Dotson et al., 2008; Panza et al., 2009).

However, despite the need for MVPE and resolution of depression in the older adults, according to the 2021 Community Integrated Health Promotion Project released by the Ministry of Health and Welfare (Welfare, M.o.H.a., 2021), exercise facilities and community programs are insufficient for the Korean older adults. As a result, the practice rate of MVPE in the older adults in Korea is 33 %, indicating that the continuous provision of physical activity facilities and programs has not

Table 3
Subgroup analysis of Subjective Cognitive Decline with the social isolation by age, MVPE, perceived depression.

Variables		SCD			
	Non-SI	SI			
	Crude/Adjusted OR[a]	Crude OR[a]	Adjusted OR[a]	95% CI	
Age					
65–69	1.00	1.33 (1.19–1.49) ***	1.08	(0.93 –	1.27)
70–74	1.00	1.33 (1.21–1.47) ***	1.19	(1.03 –	1.37) *
75–79	1.00	1.24 (1.47–1.35) ***	1.15	(1.02 –	1.29) **
≥ 80	1.00	1.23 (1.15–1.31) ***	1.17	(1.06 –	1.28) ***
MVPE					
No	1.00	1.54 (1.46–1.63) ***	1.17	(1.10 –	1.25) ***
Yes	1.00	1.09 (0.93–1.29)	0.85	(0.67 –	1.09)
Depression					
No	1.00	1.44 (1.38–1.51) ***	1.14	(1.07 –	1.22) ***
Yes	1.00	1.30 (1.15–1.48) ***	1.19	(1.05 –	1.34) **

Control variables: Sex, Educational level, monthly household income, residency region, smoking status, alcohol status, Perceived stress level, Diabetes or Hypertension diagnosis.
Note: **SI**: Social Isolation; **SCD**: Subjective Cognitive Decline; **OR**: Odds Ratio; **MVPE**: Moderate or Vigorous Physical Exercise.
[a] Weighted Odds Ratio.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

been as efficient as 45.2 % of the target set since 2010. Therefore, this study predicts that preventing SCD, along with the promotion of mental health, is possible through establishing MVPE facilities and community programs that can be easily accessed and regularly used by older adults with SI.

This study has some limitations. First, identifying a causal association between SI and SCD was not possible because the study was cross-sectional. Second, we could not use an accurate measure of cognitive function decline, such as a biomarker, owing to data limitations. In addition, SCD was self-reported and therefore did not imply a diagnosis of cognitive decline. Thus, determining whether the participants were cognitively impaired was impossible. Third, the SCD is a subjective measurement rather than an objective measurement or clinical diagnosis. Fourth, our single SCD measurement could result in a greater bias when people subjectively evaluate themselves. The mean value of several SCD results measured within a certain period (e.g., 1 week, in a single participant) may be a more reliable method to determine SCD. Finally, our study did not assess dementia, which is a confounding factor in the logistic regression model of SI and SCD.

However, this study had several strengths. First, we used data from a nationwide survey; therefore, our results represent the entire Korean population. Second, our study investigated various variables, including socioeconomic characteristics (e.g., age, sex, area of residence, educational status, marital status, occupation, and family income), chronic diseases (diabetes and hypertension), stress, and health-related behaviors (e.g., drinking alcohol and smoking). Third, this study represents a population group through imposing weights on individuals in the population. Fourth, this study focused on the association between the older adult, who are most vulnerable to SI, and SCD unlike previous studies that focused on the association between SI and depression or poverty.

5. Conclusion

We identified an association between SI and SCD using data from the 2019 KCHS. The results of this study showed that the SI group had a higher rate of SCD than the non-SI group. Particularly, a strong association between SI and SCD was observed in the MVPE and depression groups. Therefore, even if SI occurs, SCD can be prevented through educating individuals regarding the importance of participating in MVPE and managing depression. This can be achieved via preparing policies and institutional measures for exercise facilities and community programs for participation in MVPE and depression.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education (NRF-2021R1A6A3A01086576)

Appendix 1. . General characteristics of the indicators of social isolation at 2019 KCHS

Variables	Indicators of SI									
	Non-spouse		Single-person households		Non-Social activity		Non-Social network		Non-job	
	N	%	N	%	N	%	N	%	N	%
Total	26,456	(36.3)	19,096	(26.2)	1,533	(2.1)	23,947	(32.8)	24,048	(33.0)
SCD										
No	17,513	(66.2)	12,830	(67.2)	918	(59.9)	15,961	(66.7)	16,225	(67.5)
Yes	8,943	(33.8)	6,266	(32.8)	615	(40.1)	7,986	(33.3)	7,823	(32.5)
Age										
65–69	4,454	(16.8)	3,524	(18.5)	396	(25.8)	4,462	(18.6)	3,931	(16.3)
70–74	5,241	(19.8)	3,939	(20.6)	340	(22.2)	5,034	(21.0)	5,040	(21.0)
75–79	6,762	(25.6)	5,002	(26.2)	335	(21.9)	6,312	(26.4)	6,156	(25.6)
≥ 80	9,999	(37.8)	6,631	(34.7)	462	(30.1)	8,139	(34.0)	8,921	(37.1)
Sex										
Male	4,129	(15.6)	3,739	(19.6)	775	(50.6)	9,506	(39.7)	15,296	(63.6)
Female	22,327	(84.4)	15,357	(80.4)	758	(49.4)	14,441	(60.3)	8,752	(36.4)
Educational Level										
≤ Elementary school	20,273	(76.6)	14,219	(74.5)	881	(57.5)	17,672	(73.8)	13,238	(55.0)
Middle school	2,931	(11.1)	2,199	(11.5)	258	(16.8)	3,223	(13.5)	3,852	(16.0)
High school	2,322	(8.8)	1,835	(9.6)	278	(18.1)	2,327	(9.7)	4,238	(17.6)
≥ College	930	(3.5)	843	(4.4)	116	(7.6)	725	(3.0)	2,720	(11.3)
Monthly household income, thousand KRW										
≤ 100	14,930	(56.4)	14,025	(73.4)	612	(39.9)	11,485	(48.0)	9,648	(40.1)
100–200	5,014	(19.0)	3,706	(19.4)	369	(24.1)	6,354	(26.5)	6,268	(26.1)
200–300	2,289	(8.7)	828	(4.3)	219	(14.3)	2,671	(11.2)	3,248	(13.5)
≥ 300	4,223	(16.0)	537	(2.8)	333	(21.7)	3,437	(14.4)	4,884	(20.3)
Residency Region										

(*continued on next page*)

(*continued*)

Variables	Indicators of SI									
	Non-spouse		Single-person households		Non-Social activity		Non-Social network		Non-job	
	N	%	N	%	N	%	N	%	N	%
Urban area - large city	4,820	(18.2)	2,803	(14.7)	678	(44.2)	3,977	(16.6)	5,865	(24.4)
Urban area - small city	4,273	(16.2)	2,825	(14.8)	410	(26.7)	3,367	(14.1)	4,377	(18.2)
Rural area	17,363	(65.6)	13,468	(70.5)	445	(29.0)	16,603	(69.3)	13,806	(57.4)
Smoking Status (within lifetime)										
Ever	4,656	(17.6)	3,949	(20.7)	676	(44.1)	8,658	(36.2)	12,670	(52.7)
Never	21,800	(82.4)	15,147	(79.3)	857	(55.9)	15,289	(63.8)	11,378	(47.3)
Alcohol Status (within lifetime)										
Ever	14,855	(56.1)	11,068	(58.0)	1,031	(67.3)	15,123	(63.2)	17,106	(71.1)
Never	11,601	(43.9)	8,028	(42.0)	502	(32.7)	8,824	(36.8)	6,942	(28.9)
MVPE										
No	24,645	(93.2)	17,637	(92.4)	1,441	(94.0)	22,231	(92.8)	22,004	(91.5)
Yes	1,811	(6.8)	1,459	(7.6)	92	(6.0)	1,716	(7.2)	2,044	(8.5)
Depression										
Yes	2,449	(9.3)	1,847	(9.7)	288	(18.8)	2,024	(8.5)	1,959	(8.1)
No	24,007	(90.7)	17,249	(90.3)	1,245	(81.2)	21,923	(91.5)	22,089	(91.9)
Perceived Stress Level										
Very	4,326	(16.4)	3,135	(16.4)	478	(31.2)	4,853	(20.3)	3,743	(15.6)
Less	10,674	(40.3)	7,629	(40.0)	582	(38.0)	9,751	(40.7)	9,612	(40.0)
Low	11,456	(43.3)	8,332	(43.6)	473	(30.9)	9,343	(39.0)	10,693	(44.5)
Diabetes Diagnosis										
No	20,789	(78.6)	14,939	(78.2)	1,141	(74.4)	18,741	(78.3)	18,225	(75.8)
Yes	5,667	(21.4)	4,157	(21.8)	392	(25.6)	5,206	(21.7)	5,823	(24.2)
Hypertension Diagnosis										
No	10,601	(40.1)	7,653	(40.1)	720	(47.0)	10,538	(44.0)	10,406	(43.3)
Yes	15,855	(59.9)	11,443	(59.9)	813	(53.0)	13,409	(56.0)	13,642	(56.7)

Note: **KCHS:** Korea Community Health Survey / **SI**: Social Isolation / **SCD**: Subjective Cognitive Decline / **MVPE**: Moderate or Vigorous Physical Exercise.

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