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Relationship between functional limitations due to subjective cognitive decline and falling focusing exercise intensity: Results from the Korean Community Health Survey

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Abstract

Background: To explore the association between functional limitation due to subjective cognitive decline (SCD) and falling by focusing on exercise intensity in the Korean population aged 45 years and older.

Study Design: The 2019 Korean Community Health Survey (KCHS) was used to analyze 35,387 people by applying individual weights imposed from the raw data.

Methods: To analyze the association between functional limitation due to SCD and falling in the Korean population aged 45 years and older, weighted logistic regression analysis and weighted zero-inflated Poisson regression analysis were used.

Results: In both the middle-aged group and the older adult group, the functional limitation due to SCD had a higher fall experience rate and more falls than the non-functional limitation due to SCD group. Additionally, the middle-aged group and the moderate or vigorous physical exercise (MVPE) group had a higher fall experience rate and number of falls than the non-MVPE group; however, the older adult group walking regularly and performing MVPE had a lower fall experience rate and number of falls than the non-exercise group.

Conclusions: Active participation in exercise is encouraged and should lead to fewer falls in older adults. Furthermore, a group with functional limitations due to SCD should be provided with exercise guidelines and a community program and facilities that enable regular participation should be developed.

Keywords

Falling, functional limitations, physical exercise, subjective cognitive decline

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Introduction

Korea National Statistical Office in 2021 announced that the older adult population in Korea, which comprised 16.5% of the total population, had entered an aged society; the proportion of the middle-aged and older adults population in Korea is 56.5%, showing the fastest growth rate among the Organisation for Economic Cooperation and Development (OECD) member countries.[1] The increase in the middle and old age population is accompanied by various social problems[2]; in particular, it affects the onset of cognitive disorders such as Alzheimer's disease and mild cognitive impairment.[3] Therefore, recent studies on subjective cognitive decline (SCD), which is considered an

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early prevention index to arrest cognitive impairment, are being actively conducted.[4] SCD is experienced by 11% of the population aged 45 and over in the United States[3]; in Korea, 24.6% of the middle and old age population experience SCD, indicating that Korea's SCD experience rate is higher than other countries.[5] Compared to the younger population group, SCD in older adults occurs with age, resulting in decreased cognitive as well as physical function[6] and 50.6% of middle-aged and older Americans who experienced SCD experienced functional limitations.[3] According to the U.S. Centers for Disease Control and Prevention (CDC), functional limitations due to SCD are defined as the inability to perform activities due to limitations in cognitive and physical abilities to perform household chores, medication use, and social activities.[7] Naturally, functional limitation due to SCD leads to decreased physical movements, increased falls and the number of falls.[8–10] In particular, the fall experience rate of the functionally limited group in Korea was more than twice that of the non-functionally limited group.[11]

In the functional limited group, physical exercise is considered an important factor in preventing falls by slowing the rate of decline and sarcopenia.[12] Due to its importance, there is an attempt to actively intervene in exercise programs to prevent falls in middle-aged and older adults with functional limitations.[13–15] In particular, the American Geriatrics Society (AGS) provides detailed guidelines based on exercise intensity, such as regular walking exercise (RWE) and moderate or vigorous physical exercise (MVPE), which can be done by the older people in their local community.[13] The group with functional limitations has effectively reduced the fall experience rate by 32% by providing exercise guidelines with relatively easy exercise intensity, time and frequency.[14,15]

Nevertheless, as exercise programs and guidelines for fall prevention are not universally active worldwide,[16] the number of falls continues to rise,[17] resulting in accidental deaths of older adults in the United States. Furthermore, 42% of total medical expenses are related to falls.[17,18] Falls cause various social problems and are considered among the most urgent public health problems among middle-aged and older adults.[19]

Moreover, in Korea, compared to foreign countries, due to the tendency of middle-aged and older people to avoid physical exercise[20] and a lack of physical exercise programs to prevent falls,[21] the rate of physical activity is also in steady decline, from 58.3% in 2014 to 47.8% in 2019.[22] The fall experience rate among middle-aged and older adults with functional limitations is also high.[11] Compared to overseas countries, the middle-aged Korean group is more susceptible to functional limitations due to SCD and falls.

This study focuses on the rapidly growing middle-aged and older population in Korea. Previous studies show that the rate of experience with functional limitation due to SCD is high, but physical exercise is low,[1,5,8–10] and that falls and the number of falls can be reduced through physical activity.[14,15] The aim of this study was to examine the relationship between functional limitation due to SCD and falls, as well as the number of falls depending on whether exercise was undertaken and the exercise intensity of middle-aged and older adults in Korea. In addition, we intend to provide baseline data for enacting policies and institutional measures to prevent falls by advocating for physical exercise for groups vulnerable to falls.

Methods

Study design

This study used the 2019 Korea Community Health Survey (KCHS) surveyed by the Korea Ministry of Health and Welfare's KDCA (Korea Disease Control and Prevention Agency). It is a secondary analysis study that uses raw data from Korea Community Health Surveys and related pledges to investigate the association between functional limitation due to SCD and falling, the number of falling for middle-aged group and old-aged group living in Korea, and used them for analysis after approval of data requests. The KCHS was conducted to establish and evaluate health policies by securing local health statistics according to the implementation of the local government system to understand the health status of local residents. In addition, it will be used as basic data for calculating health statistics at the city, county, and district levels necessary for establishing local health care plans, expanding infrastructure, and evaluating the performance of local health projects. The Korea community health survey is an annual sample survey of 251 public health centers in 16 cities/province since 2008, and was extracted using a systematic extraction method in consideration of the number of households based on the number of households by type of house in Tong, Ban/ri. In addition, this is the data surveyed so that representative samples can be extracted from adults aged 19 or older among the sample household members. A total of 229,099 people participated in the 2019 Korean Community Health Survey, and trained investigators visited sample households in person and conducted measurement surveys and 1:1 interviews.

This study analyzed the association between functional limitation due to SCD and falling, the number of falling of the middle-aged group (45–64 years) and the old-aged (Over 65 years) group by applying individual weights imposed on 35,387 people, excluding 66,627 people under 45 years of age and people diagnosed the dementia, 126,589 missing values for functional limitation due to SCD, 59 missing values for falling and the number of falling, 437 missing values for control variables

Independent variables

Independent variable was functional limitation due to SCD. SCD was self-observed impairment of more frequent or worsening of memory loss or confusion within the prior 12 months. SCD and functional limitation due to SCD were measured by the Behavioral Risk Factor

Surveillance System (BRFSS), "During the last year, have you experienced memory loss or confusion getting worse or happening more often?"" If participants indicated that SCD was present, they were asked about functional limitation due to SCD, as follows: "During the last year, how often have your day-to-day activities (ex: cooking, cleaning, taking medicine, driving, or paying bills, etc.) been hindered or needed help because of your confusion or memory loss?"; "If you needed help in daily life because you were confused or your memory was poor, how often did you receive help when you needed it?"; and "During the last year, how often have you been disturbed in your work life, volunteering, and social activities?" The response categories included always, usually, sometimes, rarely, or never. functional limitation due to SCD was identified by memory loss or confusion that disturbed the participants' work life, volunteering, and social activities, or day-to-day activities (e.g. cooking, cleaning, taking medicine, driving, or paying bills). This study classified these responses into two groups as follows: functional limitation due to SCD group (always, usually, or sometimes) and non-functional limitation due to SCD group (rarely or never).

Dependent variables

The dependent variables in this study were falling and the number of falls. A falling was defined as one or more falls in the past 12 months. To assess the history of falling, participants were asked "whether they had fallen during the past 12 month"; If the response was "yes," the response was defined as a fall experience group, and if the response was "no," it was defined as a fall experience group. Also, the number of falls was defined in response to "How many times have you fallen during the past 1 year ?."

Control variables

In this study, predefined data such as "Sex," "Education level," "Marital status," "Residential area," and "Household monthly income" of the community health survey were selected as variables. sex was classified into "male" and "female." Marital status was classified into "married" and "single (including separated, divorced)." Education level was classified into "elementary school graduates or lower," "middle school graduates," "high school graduates," and "college graduates or higher," and residential areas were classified into "Capital area," " Metropolitan city" and " Rural area." and household monthly income was classified into "≤ 100," "100–200," "200–300" and "≥ 300." As variables for health behavior factors, predefined data such as "Smoking status," "Drinking status," "Regular Walking," "Moderate or vigorous Exercise," "Self-rated health," "Perceived stress level," "Diabetes diagnosis" and " Hypertension diagnosis" were selected as variables. Smoking status and Drinking status were classified as "Ever" and "Never." Regular Walking and Moderate or vigorous Exercise were classified into "Yes" and "No." Self-rated health and Perceived stress level were classified into "very," "less" and "low." Diabetes diagnosis and Hypertension diagnosis were classified into "Yes" and "No."

Analytical approach and statistics

In this study, to analyze the association between functional limitations due to SCD and falls, the number of falls in the middle-aged and old-aged group, after controlling the correction variables of the study subjects, to check the difference in the distribution of the dependent variable according to the independent variable, the Rao-Scott Chi square test was used for the "Whether or not falls" dependent variable. and Mann-Whitney U (for two-group comparisons) or Kruskal-Wallis test (for more than two-group comparisons) was used for the "number of falls" dependent variable. In addition, weighted logistic regression analysis was used to investigate the association between functional limitations due to SCD and falls, and weighted zero-inflated Poisson regression analysis was used to investigate the association between functional limitation due to SCD and the number of falls. For all analyses, the criterion for statistical significance was $p \leq 0.05$, two tailed. All analyses were carried out using the SAS statistical software package, version 9.4 (SAS Institute, Cary, NC, USA).

Results

Table 1 shows the general characteristics of participants in determining the relationship between functional limitation due to SCD and falls and the number of falls among the middle-aged and older adult groups.

In the middle-aged group, of the total of 14,122 participants, the fall experience rate was 18.2% ($n=2551$), and the mean number of falls was 1.83. The percentage of middle-aged people with functional limitations due to SCD was 20.2% ($n=2875$). The fall experience rate for this group was 27.7% ($n=799$), and the mean number of falls was 2.20.

In the older adult group, of the total of 21,265 participants, the fall experience rate was 24.1% ($n=5146$), and the mean number of falls was 1.79. The percentage of older people with functional limitations due to SCD was 36.3% ($n=7915$). The fall experience rate in this group was 31.3% ($n=2405$), and the mean number of falls was 2.00.

Table 2 shows the results of the control variable correction to determine the association between functional limitation due to SCD and falls and the number of falls among the middle-aged and older adult groups.

In the middle-aged group, functional limitation due to SCD group had a higher fall experience rate (Odds Ratio [OR]:1.58, 95% Confidence Interval [CI]:1.40–1.79) and

Table 1. General characteristics of subjects included for analysis.

Variables	Total		Middle-aged Group						Total		Old-aged Group					
			Falling		*p*-value[a]	Number of Falling*		*p*-value[b]			Falling		*p*-value[a]	Number of Falling*		*p*-value[b]
	N	%*	*N*	%*		Mean*	95% CI		*N*	%*	*N*	%*		Mean*	95% CI	
Total	14,122	100.0	2551	18.2		1.83	(1.79–1.86)		21,265	100	5146	24.1		1.79	(1.76–1.83)	
Functional limitation due to SCD					<0.0001			<0.0001					<0.0001			<0.0001
No	11,244	79.8	1752	15.8		1.66	(1.63–1.69)		13,350	63.7	2741	20.0		1.61	(1.57–1.64)	
Yes	2878	20.2	799	27.7		2.20	(2.15–2.25)		7915	36.3	2405	31.3		2.00	(1.97–2.04)	
Sex					<0.0001			<0.0001					<0.0001			0.0018
Male	5230	40.1	824	16.0		1.94	(1.90–1.97)		7800	39.3	1499	19.1		1.86	(1.82–1.90)	
Female	8892	59.9	1727	19.6		1.77	(1.73–1.81)		13,465	60.7	3647	27.3		1.77	(1.73–1.80)	
Marital status					<0.0001			<0.0001								0.2446
Married	11,052	78.6	1855	16.5		1.71	(1.67–1.74)		12,339	60.6	2639	20.9		1.80	(1.76–1.83)	
Single (including Separated, divorced)	3070	21.4	696	24.5		2.13	(2.09–2.17)		8926	39.4	2507	28.9		1.79	(1.76–1.83)	
Educational Level					<0.0001			0.1524					<0.0001			0.0002
Under Elementry school	2197	9.6	489	23.1		2.05	(1.99–2.10)		14,117	54.4	3712	27.2		1.88	(1.85–1.91)	
Middle school	2487	13.8	500	22.3		1.80	(1.76–1.84)		3248	18.2	699	22.4		1.65	(1.60–1.71)	
High school	5726	42.3	968	17.3		1.88	(1.83–1.92)		2714	17.8	528	19.5		1.74	(1.71–1.78)	
Over College	3712	34.3	594	16.2		1.69	(1.66–1.72)		1186	9.6	207	17.6		1.50	(1.45–1.55)	
Monthly household income					<0.0001			<0.0001					<0.0001			<0.0001
Under 100	1412	7.0	385	30.4		2.50	(2.46–2.55)		8929	31.2	2444	28.6		1.89	(1.86–1.93)	
100–200	2132	11.2	451	22.8		2.03	(1.97–2.09)		5777	27.5	1281	22.2		1.84	(1.80–1.87)	
200–300	2369	14.1	423	18.4		1.86	(1.83–1.88)		2755	15.5	578	21.0		1.62	(1.60–1.65)	
Over 300	8209	67.6	1292	16.1		1.64	(1.60–1.68)		3804	25.8	843	22.5		1.69	(1.64–1.74)	
Residency Region					0.2701			0.4716					0.6603			<0.0001
Capital area	4163	44.3	724	17.5		1.90	(1.84–1.96)		4308	39.9	1044	24.3		1.78	(1.72–1.84)	
Metropolitan city	2886	26.1	543	18.7		1.82	(1.76–1.89)		3328	23.9	764	23.5		1.67	(1.60–1.73)	
Rural area	7073	29.6	1284	18.7		1.73	(1.68–1.78)		13,629	36.2	3338	24.2		1.89	(1.85–1.93)	
Smoking Status(within lifetime)					0.1275			<0.0001					<0.0001			0.015
Ever	5056	38.4	882	17.5		1.99	(1.95–2.03)		6915	34.8	1375	19.6		1.85	(1.81–1.89)	
Never	9066	61.6	1669	18.6		1.73	(1.69–1.77)		14,350	65.2	3771	26.4		1.77	(1.74–1.80)	
Alcohol Status(within lifetime)					0.6885			0.8684					<0.0001			0.0618
Ever	12,167	88.9	2203	18.1		1.82	(1.78–1.85)		13,900	69.0	3229	22.8		1.76	(1.73–1.80)	
Never	1955	11.1	348	18.6		1.89	(1.86–1.93)		7365	31.0	1917	26.9		1.85	(1.82–1.89)	
RWE					0.6777			0.4871					<0.0001			<0.0001
No	8775	58.4	1620	18.3		1.83	(1.80–1.87)		14,418	61.4	3717	26.1		1.87	(1.84–1.90)	
Yes	5347	41.6	931	18.0		1.82	(1.78–1.85)		6847	38.6	1429	20.7		1.64	(1.60–1.68)	
MVPE					0.4879			0.6559					0.0137			0.3139

(Continued)

Table 1. (Continued)

Variables	Total		Middle-aged Group						Total		Old-aged Group					
			Falling		*p*-value[a]	Number of Falling[*]		*p*-value[b]			Falling		*p*-value[a]	Number of Falling[*]		*p*-value[b]
	N	%[*]	*N*	%[*]		Mean[*]	95% CI		*N*	%[*]	*N*	%[*]		Mean[*]	95% CI	
No	11,748	82.6	2145	18.3		1.83	(1.80–1.87)		19,248	90.0	4692	24.4		1.80	(1.77–1.83)	
Yes	2374	17.4	406	17.6		1.79	(1.76–1.82)		2017	10.0	454	21.2		1.71	(1.68–1.74)	
Self-Rated Health					<0.0001			<0.0001					<0.0001			<0.0001
Very	3446	25.3	447	13.0		1.52	(1.48–1.55)		2826	14.8	428	14.4		1.51	(1.46–1.56)	
Less	7012	51.0	1101	15.9		1.60	(1.57–1.64)		6911	35.2	1261	18.3		1.48	(1.45–1.50)	
Low	3664	23.6	1003	28.6		2.25	(2.20–2.29)		11,528	50.0	3457	31.0		1.97	(1.93–2.00)	
Perceived Stress Level					<0.0001			<0.0001					<0.0001			<0.0001
Very	4544	34.0	1081	24.4		2.08	(2.04–2.12)		4947	23.6	1601	32.0		2.02	(1.98–2.05)	
Less	7459	52.6	1154	14.9		1.63	(1.60–1.67)		9232	44.2	2094	22.2		1.68	(1.64–1.71)	
Low	2119	13.4	316	15.5		1.55	(1.45–1.66)		7086	32.2	1451	20.8		1.72	(1.69–1.75)	
Diabetes Diagnosis					0.0012			<0.0001					<0.0001			<0.0001
No	12,310	88.1	2176	17.7		1.77	(1.73–1.80)		16,523	76.3	3902	23.0		1.74	(1.71–1.77)	
Yes	1812	11.9	375	21.5		2.18	(2.12–2.25)		4742	23.7	1244	27.6		1.95	(1.90–1.99)	
Hypertension Diagnosis					0.0026			0.0678					<0.0001			0.6932
No	10,150	74.2	1779	17.5		1.79	(1.75–1.82)		9294	44.2	2133	22.1		1.79	(1.76–1.83)	
Yes	3972	25.8	772	20.1		1.93	(1.89–1.97)		11,971	55.8	3013	25.6		1.80	(1.76–1.83)	

RWE: Regular Walking Exercise; MVPE : Moderate or Vigorous Physical Exercise.
Number of Falling[*]: experienced falling down at least once in the past 1 year.
[*]Weighted.
[a]Rao Scott chi square test.
[b]Mann-Whitney U or Kruskal-Wallis test.

Table 2. Factors associated with falling in the group of Functional limitation due to SCD.

Variables	Middle-aged Group				Old-aged Group			
	Falling*		Number of Falling*		Falling*		Number of Falling*	
	AOR[a]	95% CI	IRR[b]	95% CI	AOR[a]	95% CI	IRR[b]	95% CI
Functional limitation due to SCD								
No	1.00		1.00		1.00		1.00	
Yes	1.58	(1.40–1.79)	1.41	(1.40–1.42)	1.40	(1.29–1.53)	1.41	(1.40–1.41)
Sex								
Male	1.00		1.00		1.00		1.00	
Female	1.29	(1.07–1.55)	1.04	(1.03–1.05)	1.15	(1.00–1.33)	0.91	(0.91–0.92)
Marital status								
Married	0.79	(0.69–0.90)	0.88	(0.88–0.89)	0.84	(0.76–0.93)	0.97	(0.96–0.97)
Single (Separated, divorced)	1.00		1.00		1.00		1.00	
Educational Level								
Under Elementary school	1.06	(0.89–1.26)	1.21	(1.20–1.22)	1.17	(0.96–1.43)	1.44	(1.43–1.46)
Middle school	1.19	(1.01–1.40)	1.06	(1.05–1.07)	1.12	(0.91–1.38)	1.25	(1.24–1.27)
High school	0.98	(0.86–1.13)	1.13	(1.12–1.14)	1.02	(0.83–1.25)	1.29	(1.27–1.30)
Over College	1.00		1.00		1.00		1.00	
Monthly household income								
Under 100	1.32	(1.09–1.59)	1.40	(1.39–1.41)	1.04	(0.91–1.17)	1.06	(1.05–1.07)
100–200	1.09	(0.92–1.28)	1.14	(1.13–1.15)	0.91	(0.80–1.03)	1.02	(1.02–1.03)
200–300	0.97	(0.83–1.14)	1.08	(1.07–1.08)	0.92	(0.79–1.06)	0.89	(0.88–0.90)
Over 300	1.00		1.00		1.00		1.00	
Residency Region								
Capital area	1.00		1.00		1.00		1.00	
Metropolitan city	1.05	(0.92–1.21)	0.94	(0.93–0.94)	0.93	(0.83–1.04)	0.88	(0.88–0.89)
Rural area	1.08	(0.95–1.23)	0.95	(0.94–0.95)	0.91	(0.82–1.01)	1.02	(1.01–1.02)
Smoking Status(within lifetime)								
Ever	1.05	(0.87–1.26)	1.05	(1.05–1.06)	0.90	(0.78–1.03)	0.95	(0.94–0.96)
Never	1.00		1.00		1.00		1.00	
Alcohol Status(within lifetime)								
Ever	1.12	(0.95–1.33)	1.06	(1.05–1.07)	1.01	(0.92–1.11)	0.96	(0.96–0.97)
Never	1.00		1.00		1.00		1.00	
RWE								
No	0.95	(0.85–1.06)	0.95	(0.95–0.96)	1.11	(1.01–1.21)	1.12	(1.11–1.12)
Yes	1.00		1.00		1.00		1.00	
MVPE								
No	0.91	(0.78–1.06)	0.93	(0.92–0.93)	0.88	(0.75–1.03)	0.92	(0.91–0.92)
Yes	1.00		1.00		1.00		1.00	
Self-Rated Health								
Very	1.00		1.00		1.00		1.00	
Less	1.16	(1.00–1.35)	1.19	(1.18–1.20)	1.21	(1.02–1.43)	1.13	(1.12–1.15)
Low	1.93	(1.64–2.27)	1.91	(1.89–1.93)	1.92	(1.63–2.26)	1.92	(1.90–1.94)
Perceived Stress Level								
Very	1.44	(1.20–1.73)	1.44	(1.43–1.46)	1.48	(1.33–1.66)	1.35	(1.34–1.36)
Less	0.96	(0.80–1.14)	1.00	(0.99–1.01)	1.08	(0.97–1.19)	1.01	(1.00–1.02)
Low	1.00		1.00		1.00		1.00	
Diabetes Diagnosis								
No	1.00		1.00		1.00		1.00	
Yes	0.98	(0.83–1.15)	1.05	(1.04–1.06)	1.14	(1.03–1.26)	1.19	(1.18–1.19)
Hypertension Diagnosis								
No	1.00		1.00		1.00		1.00	
Yes	1.04	(0.91–1.18)	0.96	(0.96–0.97)	1.08	(0.99–1.18)	1.00	(0.99–1.00)

RWE: Regular Walking Exercise; MVPE: Moderate or Vigorous Physical Exercise.
Falling*: Weighted logistic regression analysis predicting the likelihood of experiencing a falling in the past 1 year among all participants.
The number of falling*: Weighted zero-inflated Poisson regression analysis predicting the number of falling in the past 1 year among all participants.
*Weighted.

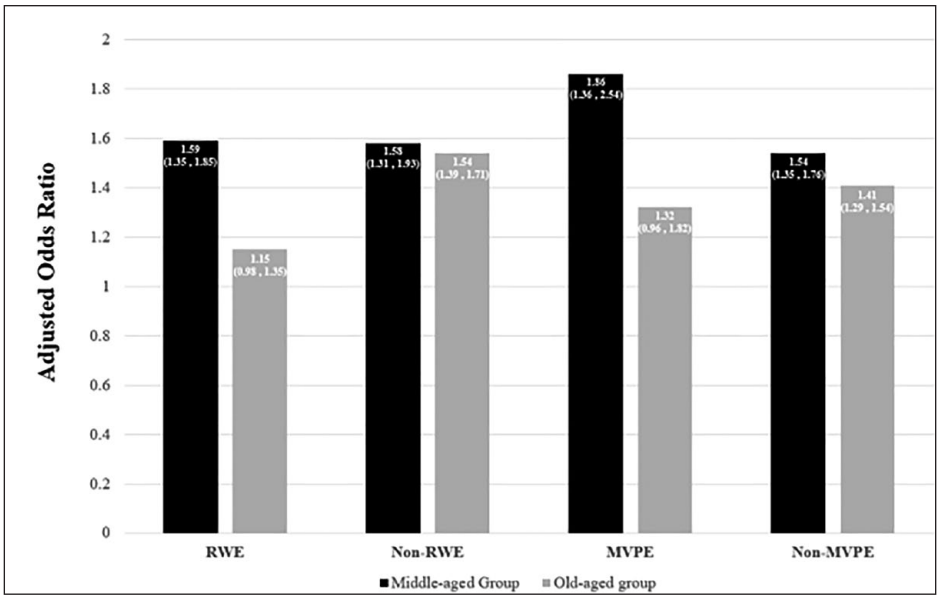

Figure 1. Adjusted effect between functional limitation due to SCD and falling by the intensity of exercise.

Table 3. The association between Functional limitation due to SCD and Falling by RWE and MVPE.

Variables	Falling[a] (Middle-aged Group)			
	Non-RWE		RWE	
	AOR[b]	95% CI	AOR[b]	95% CI
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.58	(1.35–1.85)	1.59	(1.31–1.93)
	Non-MVPE		**MVPE**	
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.54	(1.35–1.76)	1.86	(1.36–2.54)
Variables	Falling[a] (Old-aged Group)			
	Non-RWE		RWE	
	AOR[b]	95% CI	AOR[b]	95% CI
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.54	(1.39–1.71)	1.15	(0.98–1.35)
	Non-MVPE		**MVPE**	
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.41	(1.29–1.54)	1.32	(0.96–1.82)

RWE: Regular Walking Exercise; MVPE: Moderate or Vigorous Physical Exercise.
Control variables: Age, Sex, Marital status, Educational Level, Monthly household income, Residency Region, Smoking status, Alcohol Status, Regular walking, Moderate or Vigorous Exercise, Self-rated health, Perceived stress level, Diabetes diagnosis, Hypertension diagnosis.
Falling[a]: Weighted logistic regression analysis predicting the likelihood of experiencing a falling in the past 1 year among all participants.
AOR[b]: Adjusted Odds Ratio.

also had more falls (Incidence Rate Ratio [IRR]:1.41, 95% CI:1.40–1.42) than the non-functional limitation due to SCD group. In the older adult group, functional limitation due to SCD group had a higher fall experience rate (OR:1.40, 95% CI:1.29–1.53) and also had more falls (IRR:1.41, 95% CI:1.40–1.41) than the other group.

Table 3 shows the subgroup analysis results of the association between functional limitation due to SCD and falls based on exercise was undertaken and exercise intensity among middle-aged and older adult groups.

In the middle-aged group, there was no difference in the fall experience rate between the RWE and non-RWE groups, but the fall experience rate of the MVPE group was higher than the reference group (OR:1.54, 95% CI:1.35–1.76), while the fall experience rate for the non-MVPE group was higher than the reference group (OR:1.86, 95% CI:1.36–2.54).

In the older adult group, the fall experience rate of the non-RWE group was higher than the reference group (OR:1.54, 95% CI: 1.39–1.71), whereas the fall experience rate of the RWE group was higher than the reference group (OR:1.15, 95% CI:0.98–1.35). The fall experience rate of the non-MVPE group was higher than the reference group (OR:1.41, 95% CI:1.29–1.54), whereas the fall experience rate of the MVPE group was higher than the reference group (OR:1.32, 95% CI:0.96–1.82) (Figure 1).

Table 4 shows the subgroup analysis results of the association between functional limitation due to SCD and the number of falls based on exercise and exercise intensity among the middle-aged and older adult groups.

In the middle-aged group, the number of falls in the RWE group was lower than in the non-RWE group (IRR:1.31, 95% CI:1.30–1.32), but the MVPE group had a

Table 4. The association between Functional limitation due to SCD and the Number of falling by RWE and MVPE.

Variables	The number of falling[a] (Middle-aged Group)			
	Non-RWE		RWE	
	IRR[b]	95% CI	IRR[b]	95% CI
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.54	(1.53–1.55)	1.31	(1.30–1.32)
	Non-MVPE		**MVPE**	
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.38	(1.38–1.39)	1.70	(1.68–1.73)
Variables	The number of falling[a] (Old-aged Group)			
	Non-RWE		RWE	
	IRR[b]	95% CI	IRR[b]	95% CI
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.53	(1.52–1.54)	1.23	(1.22–1.24)
	Non-MVPE		**MVPE**	
Functional limitation due to SCD				
No	1.00		1.00	
Yes	1.43	(1.42–1.43)	1.41	(1.39–1.44)

RWE: Regular Walking Exercise; MVPE: Moderate or Vigorous Physical Exercise.
Control variables: Age, Sex, Marital status, Educational Level, Monthly household income, Residency Region, Smoking status, Alcohol Status, Regular walking, Moderate or Vigorous Exercise, Self-rated health, Perceived stress level, Diabetes diagnosis, Hypertension diagnosis.
The number of falling[a]: Weighted zero-inflated Poisson regression analysis predicting the number of falling in the past 1 year among all participants.
IRR[b]: Incidence Rate Ratio.

higher number of falls than the non-MVPE group (IRR:1.70, 95% CI:1.68–1.73).

In the older adult group, the number of falls in the RWE group was lower than that in the non-RWE group (IRR:1.23, 95% CI:1.22–1.24), and the number of falls in the MVPE group was lower than that in the non-MVPE group (IRR:1.41, 95% CI:1.39–1.44) (Figure 2).

Discussion

With the rapid increase of the population aged 45 and over in Korea, the rate of experience with functional limitations due to SCD has also increased.[5] Despite physiological weakness due to aging and the reduction and avoidance of physical exercise, they become more vulnerable to falls.[8–10] There have been no studies on the relationship between functional limitation due to SCD and falls. Therefore, using the 2019 KCHS on adults, this study aimed to present basic policy and institutional data to prevent falls among this vulnerable group by analyzing the functional limitations due to SCD and falls in relation to exercise and exercise intensity among middle-aged and older adults.

The results are summarized as follows: In the middle and older age groups, the group with functional limitation due to SCD had a higher fall experience rate and a higher number of falls than the non-functional limitation group. Additionally, when analyzing the association between functional limitation due to SCD and falls according to whether exercise was performed and its intensity, in the middle-aged group, the RWE group had a higher fall experience rate and lower number of falls than the non-RWE group. Furthermore, the experience rate and the number of falls for the MVPE group were higher than for the non-MVPE group. By contrast, in the older age group, the RWE and MVPE groups had lower fall experience rates and fewer falls than the non-exercise group.

The study's findings, that the fall experience rate and the number of falls in the functional limitation due to SCD group were higher than those in the non-functional limitation group, are consistent with previous studies[23–32]. SCD, which has a high incidence among middle-aged and older adults, can induce psychological effects, such as depression and stress, that could increase the risk of falls[23] In particular, according to a previous study that analyzed the relationship between SCD and falls in 92,323 middle-aged and older adults, SCD caused problems in executive functions that connect cognition to behavior, causing difficulties in walking stability and maintaining posture. The SCD group had a 1.61 OR higher fall experience rate than the non-SCD group.[24,25] Furthermore, when SCD leads to functional limitations with physical difficulties, the fall rate increases by 40%.[26] According to a previous study in the United States, the group experiencing functional limitations due to SCD needed the help of others for indoor and outdoor activities because of poor health and various diseases.[8] As a result, RWE and MVPE participation rates were significantly lower[27]; rather, the increase in sedentary static exercise did not meet the amount of physical activity needed to prevent falls.[28] Consequently, the weakening of the musculoskeletal and neuromuscular systems, which can replace the center of gravity and balance,[29,30] sarcopenia due to aging and muscle weakness due to decreased exercise, makes them more vulnerable to falls.[31,32]

In addition, the results of this study, that exercise performed in the older age group with functional limitation due to SCD was associated with decreased falls, are also consistent with previous studies.[33–36] According to a previous study,[33–35] as a result of intervening in RWE for 30 min or more, 5 days per week and MVPE for 20 min per day to prevent falls in older adults over the age of 65 with cognitive impairment, the mismatch in executive function, which was the cause of falls, was improved, and the fall experience rate decreased by 30%. In addition, as cardiac output and oxygen consumption increased, cerebral blood flow also increased. As a result, exercise in the older age

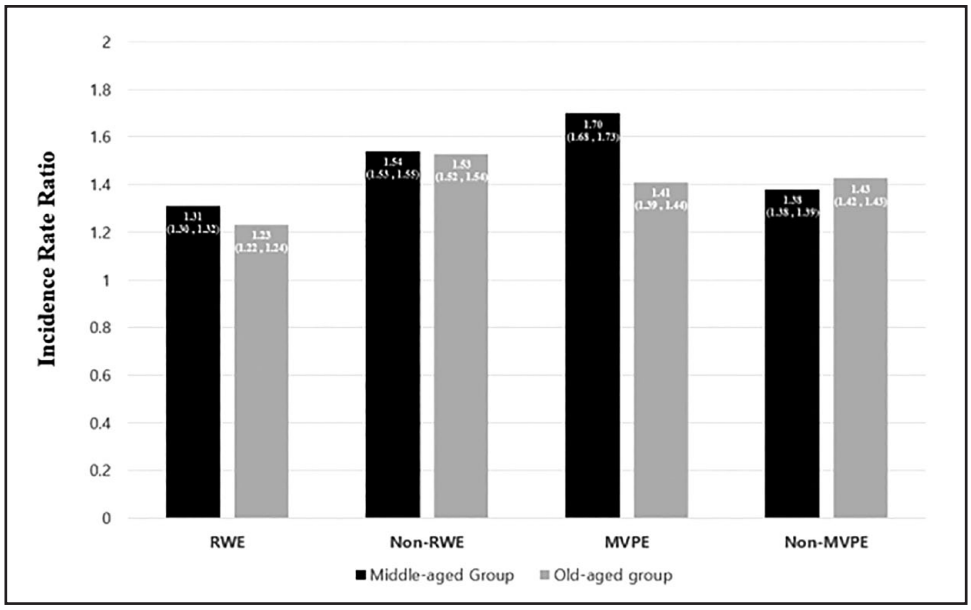

Figure 2. Adjusted effect between functional limitation due to SCD and the number of falling by the intensity of exercise.

group had a greater effect on fall prevention than in the middle-aged group.[36]

In this study, the result that the middle-aged MVPE group had a higher fall experience rate and number of falls than the non-MVPE group is consistent with previous studies.[37–39] As a result of a follow-up on 2193 Americans aged 45 and over for 5 years, the overall level of physical health of the middle-aged was higher than that of older adults. As a result of high level of outdoor activity and subjective health awareness, the fall rate of the middle age group was 24.6% higher than the older adults performing high intensity exercises. Among the middle-aged group with functional limitations, there was a stronger association with falls [37]. This was because older people had lower health awareness and used fewer outdoor activities than the middle-aged, and improving their physical health through MVPE and RWE. The fall experience rate and number of falls among the older people were relatively lower than those of the middle-aged.[37–39] In addition, according to a previous study, the fall experience rate for older people with cognitive decline and functional limitations decreased by 34% when they were provided with a customized exercise program that performed walking exercises at an appropriate and fast pace (pace of 10 m) or performed MVPE 10 times to overcome virtual obstacles.[40]

However, according to an announcement from the Korean Ministry of Health and Welfare, no exercise facilities and programs in the local community were provided for the middle-aged group. In 2019, the RWE and MVPE practice rates among middle-aged and older adults were 39.9% and 33%, respectively, which did not consistently achieve the target rates set at the beginning of the project.[41] In particular, the rate of physical exercise practice among older people, who can effectively prevent falls through exercise, was 22.4% in Korea compared to 33.5% in Japan, which was lower than in other countries.[42]

This study hopes to help prevent falls and improve physical health by encouraging appropriate policy and institutional exercise guidelines, exercise programs that encourage regular participation, and physical exercise environments for older people with functional restrictions.

This study had some limitations. First, we were unable to identify a causal relationship between functional limitation due to SCD and falls and the number of falls because the study was cross-sectional. Second, because of limited data, we were unable to use accurate measures, such as biomarkers, to measure functional limitations due to SCD. In addition, functional limitations due to SCD were self-reported and therefore did not imply a diagnosis of cognitive impairment. Thus, it was impossible to determine whether participants were cognitively impaired. Third, functional limitation due to SCD measurement could result in greater bias when people subjectively evaluate themselves. Using the mean value of several functional limitations due to SCD measured within a certain time period (e.g. 1 week) in a single participant may be a more reliable method of determining the functional limitation due to SCD. Finally, our study did not assess a dementia variable, which is a confounding factor in the weighted logistic regression model between functional limitation due to SCD and falling.

However, this study has several strengths. First, this was the first study to analyze the association between functional limitation due to SCD and falling. Second, it used national survey data as well as imposed weights on individuals in the population, so the results represent the

entire Korean population among adults over the age of 45. Third, this study investigated a variety of variables, such as socio-economic characteristics (e.g. age, gender, area of residence, education status, marital status, and family income), chronic diseases (diabetes and hypertension), perceived stress level and health-related behaviors (e.g. drinking alcohol, smoking, self-rated health). Fourth, unlike prior studies that focused on the relationship between SCD and falling or depression, this study focused on this relationship in older adults who are most vulnerable to functional limitations due to SCD and falls.

Conclusions

This study investigated the relationship between functional limitation due to SCD and falls in middle-aged and older individuals using the 2019 KCHS, a survey of adults living in Korea. The study found that the functional limitation group due to SCD had a higher number of falls than the non-functional limitation group, and falls and the number of falls were relatively reduced when RWE and MVPE were practised in the older adult group compared to the middle-aged group. In old age, the amount of physical exercise decreases rapidly, and it is predicted that falls can be reduced by encouraging active exercise participation by providing functional them with exercise guidelines for the prevention of falls, exercise programs that encourage regular participation and an exercise environment.

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Author contributions

Jeong Min Yang designed this study, performed statistical analysis, drafted and completed the manuscript. Hyeon Ji Lee contributed to the concept and design of the study, and provided statistical expertise and interpretation. Jae Hyun Kim conceived, designed and directed this study. All authors read and approved the final manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical considerations

The data is an open access dataset and did not contain any personal information on patients, therefore no ethical approval was required.

Patient consent for publication

Not required.

Data availability statement

Data are owned by and are available from the database of Korea National Health and Nutrition Examination Surveys (KNHNES) https://knhanes.kdca.go.kr/knhanes/main.do. KNHNES allows all of this data freely for any researcher who promises to follow the research ethics. The data that support the findings of this study are openly available in the Korea Community Health Survey at http://chs.kdca.go.kr/.

References

1. Statistics for the elderly, 2021.
2. Yamasaki A, Araki S, Sakai R, et al. Suicide mortality of young, middle-aged and elderly males and females in Japan for the years 1953-96: time series analysis for the effects of unemployment, female labour force, young and aged population, primary industry and population density. *Ind Health* 2008; 46(6): 541–549.
3. Taylor CA, Bouldin ED and McGuire LC. Subjective cognitive decline among adults aged ≥45 years - United States, 2015-2016. *MMWR Morb Mortal Wkly Rep* 2018; 67(27): 753–757.
4. Jessen F, Amariglio RE, Boxtel M, et al. A conceptual framework for research on subjective cognitive decline in preclinical Alzheimer's disease. *Alzheimer's & Dementia* 2014; 10(6): 844–852.
5. Lee J, Sung J and Choi M. The factors associated with subjective cognitive decline and cognitive function among older adults. *J Adv Nurs* 2020; 76(2): 555–565.
6. Jessen F, Amariglio RE, Buckley RF, et al. The characterisation of subjective cognitive decline. *Lancet Neurol* 2020; 19(3): 271–278.
7. Subjective Cognitive Decline: A public health issue, 2017.
8. Anderson LA, Deokar A, Edwards VJ, et al. Demographic and health status differences among people aged 45 or older with and without functional difficulties related to increased confusion or memory loss, 2011 Behavioral Risk Factor Surveillance System. *Prev Chronic Dis* 2015; 12: E30.
9. Cunningham C, O' Sullivan R, Caserotti P, et al. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scand J Med Science Sports* 2020; 30(5): 816–827.
10. Wang T, Wu Y, Li W, et al. Weak grip strength and cognition predict functional limitation in older Europeans. https://doi.org/10.1111/jgs.15611. *J Am Geriatr Soc* 2019; 67(1): 93–99.
11. Ministry of Health and Welfare KIFHASA. Survey of the Elderly, 2020.
12. Mijnarends DM, Koster A, Schols JM, et al. Physical activity and incidence of sarcopenia: the population-based AGES-Reykjavik Study. *Age Ageing* 2016; 45(5): 614–620.

13. Society AG, Society G, Of AA, et al. Guideline for the prevention of falls in older persons. *J Am Geriatr Soc* 2001; 49(5): 664–672.
14. Shubert TE. Evidence-based exercise prescription for balance and falls prevention: a current review of the literature. *J Geriatr Phys Ther* 2011; 34(3): 100–108.
15. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev* 2012; 2012(9): CD007146.
16. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 2012; 380(9838): 247–257.
17. Fuller GF. Falls in the elderly. *Am Fam Physician* 2000; 61(7): 2159–2168, 2173–2174.
18. Zaloshnja E, Miller TR, Lawrence BA, et al. The costs of unintentional home injuries. *Am J Prev Med* 2005; 28(1): 88–94.
19. Burns ER, Stevens JA and Lee R. The direct costs of fatal and non-fatal falls among older adults - United States. *J Saf Res* 2016; 58: 99–103.
20. Sohng KY, Sohng S and Yeom HA. Health-promoting behaviors of elderly Korean immigrants in the United States. https://doi.org/10.1046/j.1525-1446.2002.19409.x. *Public Health Nurs 2002*; 19(4): 294–300.
21. Sohng KY, Moon JS, Song HH, et al. Fall prevention exercise program for fall risk factor reduction of the community-dwelling elderly in Korea. *Yonsei Med J* 2003; 44(5): 883–891.
22. Korea Centers for Disease Control and Prevention. Health Statistics for Chronic Diseases, 2019.
23. Cuevas-Trisan R. Balance problems and fall risks in the elderly. *Clin Geriatr Med* 2019; 35(2): 173–183.
24. Shirooka H, Nishiguchi S, Fukutani N, et al. Subjective cognitive decline and fall risk in community-dwelling older adults with or without objective cognitive decline. *Aging Clin Exp Res* 2018; 30(5): 457–462.
25. Hwang IC and Ahn HY. Association between subjective cognitive decline and falls in middle-aged adults. *Int J Injury Control Saf Promot* 2022; 29: 182–185.
26. Muir SW, Gopaul K and Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age Ageing* 2012; 41(3): 299–308.
27. Miyawaki CE, Bouldin ED, Kumar GS, et al. Associations between physical activity and cognitive functioning among middle-aged and older adults. *J Nutr Health Aging* 2017; 21(6): 637–647.
28. McPhee JS, French DP, Jackson D, et al. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology* 2016; 17(3): 567–580.
29. Chan BK, Marshall LM, Winters KM, et al. Incident fall risk and physical activity and physical performance among older men: the osteoporotic fractures in men study. *Am J Epidemiol* 2007; 165(6): 696–703.
30. Moayyeri A. The association between physical activity and osteoporotic fractures: A review of the evidence and implications for future research. *Ann Epidemiol* 2008; 18(11): 827–835.
31. Xu W, Chen T, Shan Q, et al. Sarcopenia is associated with cognitive decline and falls but not hospitalization in community-dwelling oldest old in China: a cross-sectional study. *Med Sci Monit* 2020; 26: e919894–NaN1.
32. Montero-Fernández N and Serra-Rexach JA. Role of exercise on sarcopenia in the elderly. *Eur J Phys Rehabil Med* 2013; 49(1): 131–143.
33. Zhang W, Low LF, Schwenk M, et al. Review of gait, cognition, and fall risks with implications for fall prevention in older adults with dementia. *Dement Geriatr Cogn Disord* 2019; 48(1-2): 17–29.
34. Blain H, Miot S and Bernard PL. How can we prevent falls? In: Falaschi P and Marsh D. (eds) *Orthogeriatrics: the management of older patients with fragility fractures*. Berlin: Springer Copyright, 2021, pp.273–290.
35. Tiedemann A, Sherrington C, Close JC, et al. Exercise and sports science Australia position statement on exercise and falls prevention in older people. *J Sci Med Sport* 2011; 14(6): 489–495.
36. Gronek J, Boraczyński M, Gronek P, et al. Exercise in aging: be balanced. *Aging Dis* 2021; 12(5): 1140–1149.
37. Li W, Keegan TH, Sternfeld B, et al. Outdoor Falls among middle-aged and older adults: a neglected public health problem. *Am J Public Health* 2006; 96(7): 1192–1200.
38. Nagarkar A, Gadkari R and Kulkarni S. Correlates of functional limitations in midlife: a cross-sectional study in middle-aged men (45–59 years) from Pune. *J Midlife Health* 2020; 11(3): 144–148.
39. Simpson ME, Serdula M, Galuska DA, et al. Walking trends among U.S. Adults: the behavioral risk factor surveillance system, 1987-2000. *Am J Prev Med* 2003; 25(2): 95–100.
40. Schwenk M, Sabbagh M, Lin I, et al. Sensor-based balance training with motion feedback in people with mild cognitive impairment. *J Rehabil Res Dev* 2016; 53(6): 945–958.
41. Ministry of Health and Welfare and Korea Health Promotion Institute. The core competency of the integrated health promotion in communities, 2021.
42. Go NY, Ndahimana D and Kim EK. Amounts of physical activity and sedentary behavior patterns in older adults: using an accelerometer and a physical activity diary. *J Nutr Health* 2019; 52(1): 36–46.