scientific reports

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A nationwide analysis of physical inactivity and sedentary behavior among stroke survivors in Korea

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This study aimed to identify key predictors of physical inactivity and prolonged sedentary behavior among stroke survivors (SSs) using data from the 2016–2020 Korea National Health and Nutrition Surveys. Of the 28,146 participants, 633 had a history of stroke. The results showed that SSs were significantly more likely to be physically inactive and spend longer sedentary times than controls. Multivariate analysis identified that age ≥ 80 years (adjusted odds ratio [aOR] = 5.45, 95% confidence interval [CI] 1.96–15.15), lower education level (≤ 9 years) (aOR = 2.18, 95%CI 1.13–4.18), and living in rural areas (aOR = 1.91, 95%CI 1.11–3.29) were associated with aerobic physical inactivity. Female sex (aOR = 2.36, 95%CI 1.28–4.35) and lower education (aOR = 2.31, 95%CI 1.01–5.34) were linked to insufficient resistance exercises (≤ 1 day per week). Long sedentary time (≥ 8 h daily) was associated with being economically inactive (aOR = 1.90, 95%CI 1.21–2.96), single (aOR = 1.68, 95%CI 1.07–2.64), and perceiving oneself as unhealthy (aOR = 1.59, 95%CI 1.01–2.49). These findings highlight the need for targeted interventions, including community-based exercise programs and policy initiatives, to reduce sedentary behavior and promote physical activity among SSs. Implementing accessible and tailored rehabilitation strategies may help mitigate long-term health risks in this population.

Keywords Stroke, Stroke survivors, Physical activity, Resistance exercise, Sedentary time

Stroke is a leading cause of long-term disability globally, often resulting in significant impairments in physical, cognitive, and emotional functioning[1,2]. Despite advancements in acute treatment, patients with stroke frequently adopt a sedentary lifestyle, associated with adverse health outcomes[3,4]. Sedentary behavior is any waking behavior characterized by an energy expenditure of ≤ 1.5 metabolic equivalents of task while sitting or reclining. It is associated with increased risks of cardiovascular disease, obesity, diabetes mellitus, and all-cause mortality[5,6]. Previous studies have demonstrated that regular physical activity (PA) is vital for cerebrocardiovascular health and a lower stroke risk[7,8]. Prolonged sedentary time (ST) can exacerbate the risk of secondary health complications, impede functional recovery, and diminish the overall quality of life for stroke survivors (SSs)[9,10]. Therefore, promoting PA and reducing ST in SSs is crucial to post-stroke rehabilitation and secondary prevention strategies[11].

The American Stroke Association recommends an average of 40 min of moderate-to-vigorous aerobic PA (MVPA), at least three to four sessions weekly for patients with stroke who are able to engage in PA to reduce the risk of stroke recurrence[11]. The World Health Organization (WHO) recommends adequate MVPA levels for healthy adults and persons with chronic non-mobility conditions[12]. Furthermore, resistance exercise (RE) has been suggested to have a favorable strengthening effect, resulting in improved activities after stroke[12]. However, addressing sedentary behavior in SSs presents unique challenges. Even without disabling sequelae, SSs often face reduced muscle strength, fatigue, and psychological barriers, which can contribute to increased ST[13,14]. Thus, understanding the factors that influence sedentary behavior in SSs is essential to developing effective interventions to promote an active lifestyle. Factors affecting PA and ST in SS have been investigated in several studies, highlighting the role of sociodemographic and clinical characteristics. Age, sex, post-stroke physical function, and depression have been identified as influencing factors[15]. However, research on the independent association between PA patterns in SSs and various sociodemographic and health-related factors is limited,

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especially in large-scale population-based data. Furthermore, there is a lack of research on PA, RE, and ST in SSs of all ages in Korea. Despite the prevalence of stroke in Korea reaching 1.71% of the general population aged 19 and older as of 2018, the mortality rate from stroke is on the decline, so the number of SSs is increasing, especially among the younger age groups[16,17].

Thus, we aimed to identify key predictors of physical inactivity and prolonged sedentary behavior among SSs using the 2016–2020 Korea National Health and Nutrition Examination Survey (KNHANES) data. By clarifying these predictors, this study seeks to provide evidence to inform targeted interventions and public health strategies to promote PA and reduce ST among SSs.

Results

Baseline characteristics of participants according to stroke status

Of the total 28,146 participants, 633 had a history of stroke. SSs were older ($p < .001$) and more likely to be male (57.1% vs. 49.8%, $p = .002$). The prevalence of a BMI of ≥ 25.0 kg/m² (41.3% vs. 35.6%), hypertension (68.0% vs. 18.6%), diabetes mellitus (29.0% vs. 7.3%), and ischemic heart disease (10.7% vs. 2.1%) were all significantly higher in SSs ($p < .001$). The prevalence of current smoking did not differ significantly between the two groups (17.6% vs. 21.0%, $p = .100$).

Regarding social characteristics, SSs were statistically significantly more likely to have less education, lower household income, and receive medical aid. SSs were also significantly more likely to feel poor about their health (47.8% vs. 16.5%, $p < .001$) (Supplementary Table S1).

Aerobic PA, RE, and ST according to stroke status

The proportion of participants who reported getting enough MVPA was significantly lower among SSs (66.2% vs. 53.6%, $p < .001$). SSs were also less likely to report doing RE at least twice weekly (18.0% vs. 22.6%, $p = .022$). In the overall age group, the amount of ST by stroke history ($p = .151$) did not differ significantly. However, when categorized by age group, SSs, particularly in the 70–79 age group, spent significantly more ST daily (9.7 ± 0.3 h) compared to the remaining population (8.6 ± 0.1 h, $p < .001$). Stroke survivors aged 70–79 spent an average of 9.7 h per day sedentary, 1.1 h longer than the control group (8.6 h, $p < .001$). This difference was more pronounced than in younger age groups, where the difference was smaller and not statistically significant (e.g., 50–59 years: 8.3 vs. 7.6 h, $p = .166$) (Table S2 and Fig. 1).

PA according to characteristics of SSs

MVPA enforcement rate in SSs reduced with increasing age ($p < .001$) and without economic activity (27.6% vs. 72.4% $p < .001$). The lower the level of education, the lower the MVPA rate; aerobic activity was higher in those with a college degree or higher (56.1% vs. 43.9%, $p < .001$). Participants living in rural areas were less likely to practice MVPA than those living in cities (22.4% vs. 77.6%, $p < .001$). Furthermore, participants with chronic diseases were less likely to practice MVPA (30.3% vs. 69.7%, $p < .001$) (Table 1).

RE according to characteristics of SSs

We analyzed whether RE was performed with sufficient frequency (≥ 2 days/week) among SSs according to individual characteristics. Women were less likely to practice REs than men (9.3% vs. 24.5%, $p < .001$), and participants without a spouse were less likely to practice RE than married ones (8.6% vs. 22.1%, $p = .001$). Participants with a lower level of education were less likely to practice RE ($p < .001$), and the lower the household income, the lower the RE rate ($p = .032$). Participants in rural areas were less likely to perform RE than those in cities (11.6% vs. 19.8%, $p = .040$). SSs with poor perceived health (13.0% vs. 31.8%, $p = .005$) and those who did not receive health checkups periodically were less likely to perform RE (11.7% vs. 21.1%, $p = .012$) (Table 2).

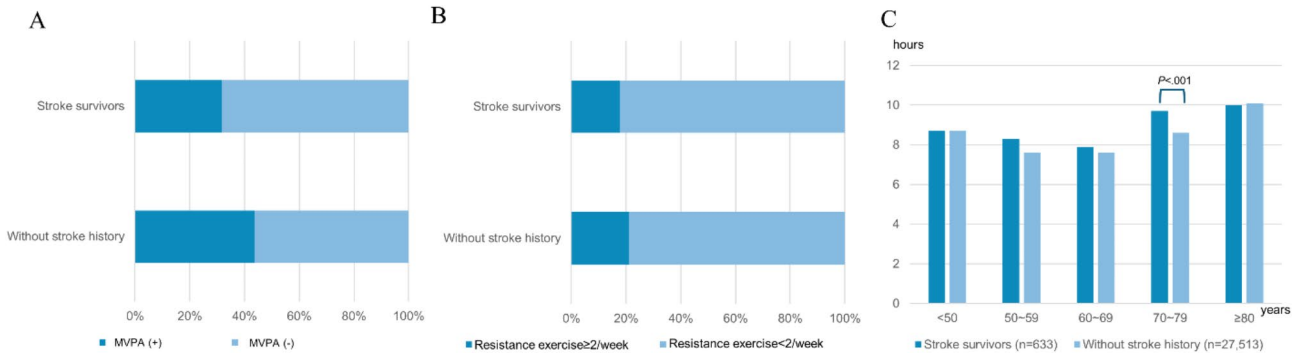

Fig. 1. Aerobic physical activity, resistance exercise frequency, and sedentary time by age in stroke survivors. (**A**) Aerobic physical activity practice was compared between stroke survivors and participants without a history of stroke. Moderate-to-vigorous aerobic physical activity was defined as ≥ 75 min of vigorous-intensity exercise weekly, ≥ 150 min of moderate-intensity exercise weekly, or a combination of vigorous- and moderate-intensity activity. (**B**) Comparison of resistance exercise frequency between stroke survivors and participants without a history of stroke. (**C**) Comparing sedentary time between stroke survivors and those without a history of stroke by age.

Characteristics	Categories	Moderate to vigorous aerobic Physical activity		p-value
		Yes	No	
		(*n* = 200)	(*n* = 433)	
Age	< 50	25 (58.3)	19 (41.7)	< 0.001
	50–59	36 (40.2)	54 (59.8)	
	60–69	61 (32.2)	117 (67.8)	
	70–79	66 (30.8)	157 (69.2)	
	≥ 80	12 (12.0)	86 (88.0)	
Sex	Male	115 (35.7)	226 (64.3)	0.322
	Female	85 (31.3)	207 (68.7)	
BMI (kg/m^2)	< 18.5	0 (0.0)	11 (100.0)	0.226
	18.5–22.9	57 (31.5)	131 (68.5)	
	23.0–24.9	54 (35.5)	114 (64.5)	
	≥ 25.0	89 (35.7)	177 (64.3)	
Marital status	With spouse	145 (35.1)	293 (64.9)	0.364
	Without spouse	55 (30.8)	140 (69.2)	
Family member	1	40 (31.5)	101 (68.5)	0.207
	2	90 (30.7)	207 (69.3)	
	3	45 (43.5)	65 (56.5)	
	≥ 4	25 (32.2)	60 (67.8)	
Economic activity	Employed	88 (44.2)	130 (55.8)	0.001
	Unemployed	112 (27.6)	303 (72.4)	
Education	≤Middle-school	107 (24.8)	311 (75.2)	< 0.001
	High-school graduate	55 (42.3)	86 (57.7)	
	≥College	38 (56.1)	36 (43.9)	
Household income	Low	64 (21.2)	208 (78.8)	< 0.001
	Lower middle	62 (36.7)	115 (63.3)	
	Upper middle	46 (43.8)	70 (56.2)	
	High	28 (46.4)	40 (53.6)	
Residential area	Urban	160 (37.0)	303 (63.0)	0.002
	Rural	40 (22.4)	130 (77.6)	
Health insurance	Medicare	175 (34.8)	378 (65.2)	0.176
	Medical aid	25 (26.1)	55 (73.9)	
Comorbidities	Yes	150 (30.3)	366 (69.7)	0.004
	No	50 (47.5)	67 (52.5)	
Self-rated health	Good	29 (41.1)	46 (58.9)	0.078
	Fair	93 (37.7)	164 (62.3)	
	Poor	78 (28.6)	223 (71.4)	
Smoking status	Current smoker	36 (40.4)	69 (59.6)	0.195
	Never/Past smoker	164 (32.4)	364 (67.6)	
Drinking status	Risky drinking	23 (40.3)	30 (59.7)	0.358
	Non-risky drinking	177 (33.0)	403 (67.0)	
Health screening	Yes	147 (36.4)	279 (63.6)	0.124
	No	53 (28.6)	154 (71.4)	

Table 1. Aerobic physical activity according to characteristics of stroke survivors.

ST according to characteristics of SSs

Using Chi-square tests, we verified whether ST was significantly > 8 h daily according to the characteristics of SSs. Our analysis revealed that ST was relatively long for those aged > 70 years ($p = .002$) and without a spouse (75.4% vs. 56.4%, $p < .001$). Those with no economic activity (70.6% vs. 47.9%, $p < .001$) and low household income had a relatively long ST ($p = .012$). SSs with chronic diseases (64.9% vs. 51.7%, $p = .031$), without high-risk drinking (63.9% vs. 48.5%, $p = .039$), or who did not undergo health checkups engaged in STs relatively above 8 h daily (69.9% vs. 30.1%, $p = .020$) (Table 3).

Characteristics	Categories	Muscular exercise		p-value
		≥2 days/week	≤1 day/week	
		(*n* = 113)	(*n* = 520)	
Age	< 50	12 (25.1)	32 (74.9)	0.295
	50–59	15 (20.1)	75 (79.9)	
	60–69	36 (20.0)	142 (80.0)	
	70–79	40 (15.5)	183 (84.5)	
	≥80	10 (9.9)	88 (90.1)	
Sex	Male	88 (24.5)	253 (75.5)	< 0.001
	Female	25 (9.3)	267 (90.7)	
BMI (kg/m^2)	< 18.5	1 (0.5)	10 (99.5)	0.1
	18.5–22.9	32 (16.7)	156 (83.3)	
	23.0–24.9	35 (23.2)	133 (76.8)	
	≥25.0	45 (16.2)	221 (83.8)	
Marital status	With spouse	94 (22.1)	344 (77.9)	0.001
	Without spouse	19 (8.6)	176 (91.4)	
Family member	1	15 (10.4)	126 (89.6)	0.133
	2	56 (17.8)	241 (82.2)	
	3	21 (18.6)	89 (81.4)	
	≥4	21 (25.1)	64 (74.9)	
Economic activity	Employed	49 (22.6)	169 (77.4)	0.057
	Unemployed	64 (15.3)	351 (84.7)	
Education	≤Middle-school	52 (12.0)	366 (88.0)	< 0.001
	High-school graduate	36 (22.5)	105 (77.5)	
	≥College	25 (34.7)	49 (65.3)	
Household income	Low	36 (12.2)	236 (87.8)	0.032
	Lower middle	31 (17.5)	146 (82.5)	
	Upper middle	29 (26.2)	87 (73.8)	
	High	17 (21.6)	51 (78.4)	
Residential area	Urban	91 (19.8)	372 (80.2)	0.04
	Rural	22 (11.6)	148 (88.4)	
Health insurance	Medicare	97 (18.2)	456 (81.8)	0.732
	Medical aid	16 (16.6)	64 (83.4)	
Comorbidities	Yes	87 (17.1)	429 (82.9)	0.345
	No	26 (21.5)	91 (78.5)	
Self-rated health	Good	21 (31.8)	54 (68.2)	0.005
	Fair	47 (19.6)	210 (80.4)	
	Poor	45 (13.0)	256 (87.0)	
Smoking status	Current smoker	18 (20.0)	87 (80.0)	0.633
	Never/Past smoker	95 (17.6)	433 (82.4)	
Drinking status	Risky drinking	11 (21.3)	42 (78.7)	0.547
	Non-risky drinking	102 (17.6)	478 (82.4)	
Health screening	Yes	87 (21.1)	339 (78.9)	0.012
	No	26 (11.7)	181 (88.3)	

Table 2. Resistance exercise according to characteristics of stroke survivors.

Factors associated with API, insufficient RE, and long ST above 8 h in SSs

First, using uni- and multivariate analyses, we determined factors associated with API that prevented SSs from adhering to WHO recommendations. Our multivariate logistic regression analysis results showed that the probability of API was significantly higher in those aged > 80 years than in those aged < 50 years (adjusted odds ratio [aOR] = 5.45, 95% confidence interval [CI] 1.96–15.15, $p = .001$), in middle-school graduates or lower (aOR = 2.18, 95% CI 1.13–4.18, $p = .019$) compared to college or above, and in those living in rural areas than in those living in cities (aOR = 1.91, 95% CI 1.11–3.29, $p = .020$) (Table 4).

Next, we explored the factors associated with RE ≤ 1 day per week. Our univariate logistic regression showed a significant probability ($p < .10$) for all variables except health insurance, BMI, comorbidities, and current smoking. The multivariate logistic regression analysis revealed that women were significantly more likely to not perform RE than men (aOR = 2.36, 95% CI 1.28–4.35, $p = .006$). Furthermore, SSs with a low education level were more likely not to perform RE (aOR = 2.31, 95% CI 1.01–5.34, $p = .048$) (Table 5). The sensitivity analysis

Characteristics	Categories	Sitting hours		p-value
		≥ 8 h	< 8 h	
		(*n* = 393)	(*n* = 240)	
Age	< 50	24 (58.5)	20 (41.5)	0.002
	50–59	51 (55.0)	39 (45.0)	
	60–69	93 (51.0)	85 (49.0)	
	70–79	154 (73.1)	69 (26.9)	
	≥ 80	71 (74.0)	27 (26.0)	
Sex	Male	203 (59.8)	138 (40.2)	0.237
	Female	190 (65.3)	102 (34.7)	
BMI (kg/m^2)	< 18.5	9 (70.9)	2 (29.1)	0.46
	18.5–22.9	115 (60.8)	73 (39.2)	
	23.0–24.9	99 (56.8)	69 (43.2)	
	≥ 25.0	170 (66.3)	96 (33.7)	
Marital status	With spouse	251 (56.4)	187 (43.6)	< 0.001
	Without spouse	142 (75.4)	53 (24.6)	
Family member	1	95 (66.1)	46 (33.9)	0.43
	2	185 (64.5)	112 (35.5)	
	3	65 (60.2)	45 (39.8)	
	≥ 4	48 (55.4)	37 (44.6)	
Economic activity	Employed	104 (47.9)	114 (52.1)	< 0.001
	Unemployed	289 (70.6)	126 (29.4)	
Education	≤Middle-school	264 (64.7)	154 (35.3)	0.397
	High-school	83 (57.0)	58 (43.0)	
	≥College	46 (60.6)	28 (39.4)	
Household income	Low	187 (72.1)	85 (27.9)	0.012
	Lower middle	104 (58.4)	73 (41.6)	
	Upper middle	62 (52.8)	54 (47.2)	
	High	40 (57.7)	28 (42.3)	
Residential area	Urban	296 (63.6)	167 (36.4)	0.208
	Rural	97 (57.1)	73 (42.9)	
Health insurance	Medicare	344 (61.5)	209 (38.5)	0.374
	Medical aid	49 (67.3)	31 (32.7)	
Comorbidities	Yes	329 (64.9)	187 (35.1)	0.031
	No	64 (51.7)	53 (48.3)	
Self-rated health	Good	42 (53.4)	33 (46.6)	0.06
	Fair	149 (58.0)	108 (42.0)	
	Poor	202 (67.9)	99 (32.1)	
Smoking status	Current smoker	73 (64.4)	32 (35.6)	0.662
	Never/past smoker	320 (61.7)	208 (38.3)	
Drinking status	Risky drinking	30 (48.5)	23 (51.5)	0.039
	Non-risky drinking	363 (63.9)	217 (36.1)	
Health screening	Yes	252 (58.3)	174 (41.7)	0.02
	No	141 (69.9)	66 (30.1)	

Table 3. Sedentary time according to general characteristics of stroke survivors.

results conducted using the modified criteria also showed that age over 80 years (aOR = 4.21, 95%CI 1.56–12.08, $p = .026$), education level below middle school (aOR = 1.87, 95%CI 1.56–5.62, $p = .033$), and living in rural areas (aOR = 1.78, 95%CI 1.45–2.55, $p = .044$) were independently predictive of physical inactivity. In addition, when the RE criteria were changed to less than once a week, there was a significant correlation with female not doing muscle-strengthening exercises (aOR = 1.89, 95%CI 1.45–2.96, $p = .027$) (Table S3, S4).

Finally, when examining the factors associated with an ST of over 8 h per day, the multivariate logistic regression analysis results revealed that the probability of ST of over 8 h was significantly higher among those without a spouse (aOR = 1.68, 95% CI 1.07–2.64, $p = .024$), those with no economic activity (aOR = 1.9, 95% CI 1.21–2.96, $p = .005$), and those with poor perceived health (aOR = 1.59, 95% CI 1.01–2.49, $p = .044$) (Table 6). We explored factors significantly associated with ST of six hours or more per day for sensitivity analysis. Finally, economic inactivity (aOR = 1.75, 95%CI 1.11–2.32, $p = .042$), living without a spouse (aOR = 1.92, 95%CI 1.14–

Characteristics	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Age (ref: <50)				
50–59	2.08 (0.88–4.93)	0.096	1.91 (0.79–4.60)	0.150
60–69	2.95 (1.32–6.60)	0.008	1.85 (0.80–4.29)	0.152
70–79	3.15 (1.42–6.98)	0.005	1.62 (0.69–3.79)	0.268
≥80	10.24 (3.76–27.86)	<0.001	5.45 (1.96–15.15)	0.001
Sex (female)	1.22 (0.82–1.81)	0.322		
Living without spouse	1.22 (0.80–1.85)	0.364		
Family member (ref: ≥4)				
1	1.03 (0.52–2.05)	0.925		
2	1.07 (0.58–1.98)	0.827		
3	0.62 (0.30–1.27)	0.191		
Non-economic activity	2.07 (1.36–3.16)	0.001	1.43 (0.88–2.32)	0.149
Education (ref: ≥college)				
≤Middle school	3.87 (2.15–6.98)	<0.001	2.18 (1.13–4.18)	0.019
High school graduate	1.75 (0.91–3.35)	0.093	1.32 (0.66–2.62)	0.430
Household income (ref: high)				
Low	3.21 (1.76–5.87)	<0.001	1.52 (0.73–3.15)	0.259
Lower middle	1.49 (0.76–2.90)	0.241	0.98 (0.47–2.06)	0.959
Upper middle	1.11 (0.55–2.25)	0.775	0.93 (0.44–1.97)	0.851
Residential area (rural)	2.04 (1.28–3.24)	0.003	1.91 (1.11–3.29)	0.020
Medical aid	0.66 (0.37–1.21)	0.178		
BMI (ref: ≥25.0)				
<23.0	1.31 (0.82–2.11)	0.263		
23.0–24.9	1.01 (0.60–1.71)	0.971		
Comorbidities	2.09 (1.27–3.43)	0.004	1.33 (0.78–2.25)	0.295
Self-rated health (ref: fair)				
Good	0.87 (0.46–1.63)	0.655	1.26 (0.65–2.42)	0.493
Poor	1.51 (1.00–2.27)	0.049	1.45 (0.93–2.26)	0.097
Current smoking	0.71 (0.42–1.20)	0.196		
No high-risk drinking	1.37 (0.70–2.70)	0.359		
No health screening	1.43 (0.91–2.25)	0.125		

Table 4. Factors associated with aerobic physical inactivity in stroke survivors. BMI, body mass index; Ref, reference; OR, odds ratio; CI, confidence interval.

3.45, $p = .017$), and poor perceived health (aOR 1.69, 95%CI 1.02–2.32, $p = .036$) independently predicted ST of over 6 h per day (Table S5).

Discussion

Our study highlighted significant differences and associated factors in MVPA, RE, and ST among SSs compared to the general population. SSs were found to be less physically active and had longer STs when aged ≥70 years. This study's comprehensive analysis of KNHANES data provided valuable insights into behavioral patterns and contributing factors associated with physical inactivity and longer sedentary behavior in SSs.

Our results revealed that SSs without daily life limitations engaged in significantly less aerobic PA and RE compared to individuals with no stroke history. This aligned with previous research indicating that SSs often face substantial barriers to engaging in PA[18]. These barriers include physical limitations due to index stroke, reduced muscle strength, fatigue, and psychological issues, such as depression and anxiety[19]. The findings underscore the critical need for tailored, targeted, and structured interventions that address these barriers to promote PA and reduce sedentary behavior among SSs. Community-based rehabilitation programs tailored to SSs, such as supervised group exercise programs within local community centers, could improve participation. Additionally, policy-level interventions such as financial incentives for PA participation, subsidies for gym memberships could help address the disparities identified in this study.

We identified several factors significantly associated with API in SSs. Age was a critical factor, with older SSs exhibiting less aerobic PA. This could be attributed to the cumulative effects of aging and stroke-related impairments, which contribute to reduced mobility and increased sedentary behavior[20]. Additionally, in Korea, cultural factors may further influence exercise behavior in older SSs. Traditional views on aging often emphasize rest rather than active rehabilitation, which may discourage older individuals from engaging in structured exercise programs in Korea. Future interventions should consider culturally tailored approaches, such as public health campaigns that reframe exercise as essential for healthy aging. Education levels were also significant predictors of aerobic PA and RE, suggesting that sociodemographic status is crucial in influencing

Characteristics	Crude OR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Age (ref: <50)				
50–59	1.33 (0.48–3.64)	0.58	1.45 (0.52–4.03)	0.471
60–69	1.33 (0.53–3.34)	0.538	1.22 (0.45–3.30)	0.694
70–79	1.83 (0.73–4.57)	0.195	1.47 (0.50–4.31)	0.481
≥80	3.03 (0.99–9.25)	0.051	2.45 (0.73–8.15)	0.145
Sex (female)	3.16 (1.75–5.68)	<0.001	2.36 (1.28–4.35)	0.006
Living without spouse	2.99 (1.55–5.76)	<0.001	2.13 (0.85–5.31)	0.105
Family member (ref: ≥4)				
1	2.88 (1.18–6.99)	0.02	0.79 (0.23–2.79)	0.717
2	1.55 (0.78–3.09)	0.213	0.95 (0.42–2.12)	0.896
3	1.46 (0.63–3.38)	0.371	1.26 (0.51–3.09)	0.616
Non-economic activity	1.62 (0.98–2.66)	0.058	0.84 (0.43–1.62)	0.599
Education (ref: ≥college)				
≤Middle-school	3.89 (1.99–7.59)	<0.001	2.31 (1.01–5.34)	0.048
High-school graduate	1.83 (0.88–3.80)	0.105	1.44 (0.66–3.11)	0.357
Household income (ref: high)				
Low	1.98 (0.98–4.00)	0.056	0.82 (0.30–2.25)	0.699
Lower middle	1.30 (0.60–2.80)	0.505	0.78 (0.32–1.94)	0.597
Upper middle	0.78 (0.36–1.67)	0.518	0.55 (0.23–1.32)	0.181
Residential area (rural)	1.88 (1.02–3.43)	0.042	1.67 (0.87–3.21)	0.126
Medical aid	0.89 (0.47–1.70)	0.732		
Body mass index (kg/m^2) (ref: ≥25.0)				
<23.0	1.03 (0.59–1.80)	0.93		
23.0–24.9	0.64 (0.35–1.15)	0.136		
Comorbidities	1.33 (0.73–2.43)	0.346		
Self–rated health (ref: fair)				
Good	0.52 (0.26–1.06)	0.073	0.82 (0.39–1.75)	0.615
Poor	1.63 (0.96–2.78)	0.073	1.63 (0.91–2.90)	0.101
Current smoking	0.86 (0.45–1.63)	0.633		
No high–risk drinking	1.27 (0.58–2.79)	0.547		
No health screening	2.01 (1.16–3.48)	0.012	1.72 (0.92–3.19)	0.087

Table 5. Factors associated with insufficient resistance exercise (≤1 day per week) in stroke survivors.

health behaviors post-stroke. Interventions aimed at encouraging PA should consider disparities in educational level and strive to provide accessible and understandable resources and dedicated support for SSs with a low educational level. Notably, MVPA differed depending on where the participant lived. SSs living in rural areas were more likely to have insufficient aerobic PA. Previous studies have also reported that the frequency and intensity of PA are stronger in urban areas in Korea[21]. This suggests that the geographical distribution of suitable rehabilitation exercise facilities for SSs in Korea may be skewed toward urban areas. In particular, the lack of rehabilitation facilities in rural areas of Korea is a point that contrasts with research in the West, where the frequency and intensity of SSs' PA in rural areas is higher[22]. Further research is required to understand these factors better, and future policy efforts may be required to address the urban-rural disparity.

Gender differences were notable in RE, with women significantly less likely to engage in such activity than men. This gender disparity may be due to cultural factors, differing motivation levels, or varying perceptions of RE's importance[23]. The cultural background may have influenced this in Korea, where weight training is mainly considered for men[24]. Targeted interventions considering gender-specific barriers and motivators are necessary to promote equitable engagement in RE among male and female SSs.

Compared to the general population, we found that SSs, especially those aged 70–79, spend more time sitting. This suggests that physical inactivity due to stroke sequelae and aging in this age group is having a synergistic effect on SSs[25]. It also means a lack of social support for PA and exercise programs tailored to the age group. More targeted, active rehabilitation programs and treatment may be needed. In addition, our study found that SSs without a spouse and those with no economic activity had more extended ST periods. The lack of social support and economic activity likely contributes to a more sedentary lifestyle; hence, social and community support is important to mitigate sedentary behavior[26]. The study also highlighted the impact of health status and perceived health on PA and ST. SSs with chronic diseases, such as hypertension, diabetes, kidney disease, asthma, and cancer, were more likely to have longer ST. These comorbid conditions can further complicate the physical and psychological challenges faced by SSs, making it more difficult for them to engage in regular PA[27]. Perceived health was another significant factor, with those perceiving their health as poor being less likely to engage in PA and more likely to be sedentary. This finding underscores the importance of addressing stroke rehabilitation

Characteristics	unadjusted OR (95% CI)	*p*–value	adjusted OR (95% CI)	*p*–value
Age (ref: <50)				
50–59	0.87 (0.38–1.98)	0.737	0.81 (0.34–1.88)	0.616
60–69	0.74 (0.35–1.57)	0.429	0.61 (0.27–1.40)	0.242
70–79	1.93 (0.96–3.87)	0.063	1.40 (0.65–3.01)	0.395
≥80	2.02 (0.89–4.63)	0.095	1.26 (0.51–3.11)	0.622
Sex (female)	1.27 (0.86–1.88)	0.236		
Living without spouse	2.37 (1.55–3.63)	<0.001	1.68 (1.07–2.64)	0.024
Family member (ref: ≥4)				
1	1.57 (0.85–2.92)	0.153		
2	1.46 (0.82–2.61)	0.200		
3	1.22 (0.62–2.37)	0.568		
Non–economic activity	2.61 (1.75–3.88)	<0.001	1.90 (1.21–2.96)	0.005
Education (ref: ≥college)				
≤Middle-school	1.19 (0.64–2.22)	0.582		
High-school graduate	0.86 (0.44–1.70)	0.672		
Household income (ref: high)				
Low	1.90 (1.02–3.53)	0.043	0.81 (0.39–1.68)	0.573
Lower middle	1.03 (0.53–2.00)	0.930	0.70(0.35–1.41)	0.314
Upper middle	0.82 (0.40–1.68)	0.591	0.62 (0.29–1.36)	0.236
Residential area (rural)	0.76 (0.50–1.16)	0.208		
Medical aid	0.78 (0.45–1.36)	0.375		
Body mass index(kg/m^2) (ref: ≥25.0)				
<23.0	0.81 (0.52–1.26)	0.342		
23.0–24.9	0.67 (0.41–1.10)	0.111		
Comorbidities	1.72 (1.05–2.83)	0.031	1.32 (0.75–2.32)	0.337
Self-rated health (ref: fair)				
Good	0.83 (0.44–1.57)	0.568	1.13 (0.60–2.13)	0.697
Poor	1.54 (1.00–2.36)	0.050	1.59 (1.01–2.49)	0.044
Current smoking	1.12 (0.67–1.89)	0.662		
No high-risk drinking	1.88 (1.03–3.44)	0.041	1.26 (0.62–2.53)	0.524
No health screening	1.66 (1.08–2.56)	0.021	1.41 (0.89–2.23)	0.144

Table 6. Factors associated with sedentary time above 8 h in stroke survivors.

programs' physical and psychological health aspects. Improving self-efficacy and providing psychological support could play a crucial role in encouraging SSs to reduce ST and increase PA[28].

The sensitivity analysis confirmed our main findings: advanced age, low education, and rural residency remained key predictors of physical inactivity, even with modified aerobic activity criteria. Notably, the association between female sex and insufficient resistance exercise persisted when defined as less than one session per week. Furthermore, economic inactivity, lack of a spouse, and poor perceived health continued to predict prolonged sedentary behavior when applying the more lenient threshold of six or more hours per day. These consistent associations across varying analytical parameters highlight the robustness of our results and emphasize the importance of tailored interventions targeting these vulnerable subgroups.

This study has some limitations. First, its cross-sectional design prevents establishing causality between the identified factors and sedentary behavior. However, identifying sociodemographic, economic, and health factors related to PA and ST in a large population can still guide future policies and interventions. Second, reliance on self-reported data for PA, ST, and other variables may introduce recall and social desirability biases[29]. Participants may have overestimated their PA levels or underestimated their ST due to perceived social expectations regarding healthy behaviors. Additionally, the retrospective nature of self-reporting may have led to misclassification, particularly among older adults who may have difficulty accurately recalling their daily activity patterns. Third, the study population was derived from the KNHANES in Korea, which may limit the generalizability of the findings to other populations. Finally, the study did not explore the potential impact of interventions on reducing sedentary behavior and increasing PA among SSs. Future research should focus on evaluating the effectiveness of different intervention strategies in providing evidence-based recommendations for practice.

In conclusion, SSs were less physically active and had longer ST, especially at older ages. This study highlights the need for multifaceted interventions to promote PA. Stroke rehabilitation guidelines should include structured physical activity programs for older and socioeconomically disadvantaged survivors. Community-based initiatives, such as subsidized exercise programs and outreach to promote resistance training, can help

address these challenges. Further research should focus on evaluating the effectiveness of such interventions in improving PA participation and long-term health outcomes in SSs.

Methods

Data and study population

In this study, we obtained data from the 2016 to 2020 Korea National Health and Nutrition Examination Survey (KNHANES), a cross-sectional and national survey conducted by the Korea Disease Control and Prevention Agency[30]. KNHANES was designed to assess the health status, health behavior, and nutritional status of individuals in South Korea to provide basic data for developing nationwide health policies. All data analyzed in this study were fully anonymized after participants provided informed consent. The Seoul National University Hospital Institutional Review Board approved this study (approval number: H-2110-124-1264). All research-related procedures have been performed in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants.

Over 5 years (2016–2020), 39,738 persons were surveyed. We extracted 32,128 participants aged ≥ 19 years, with 30,392 having no missing values for selecting key variables. We excluded those with significant impairments or limitations in performing activities of daily living, as these can significantly impact PA and ST. Therefore, 2,246 individuals who answered "yes" to the question "Do you currently have any limitations in your daily and social life due to a health problem or physical or mental disability?" were considered activity-limited participants and excluded[31]. The stroke group was determined based on the KNHANES questionnaire items. Participants who answered "yes" to the question "Has a doctor or other health care professional ever told you have had a stroke?" were identified as having had a stroke history and were classified as SSs in the analysis[32]. This study included 28,146 persons, including 633 individuals with a history of stroke (Supplementary Fig. S1). Participants with significant impairments limiting daily activities were excluded to ensure that observed differences in PA and sedentary behavior were not solely driven by severe disability rather than voluntary lifestyle choices. Also, the level of disability among SSs may also vary, but the KNHANES dataset does not allow for a detailed understanding of this. However, this exclusion criterion may limit the generalizability of our findings to SSs with more severe functional impairments, who may exhibit even greater physical inactivity and sedentary behavior.

Study variables

Participants' PA and ST data were collected through a questionnaire. MVPA, a dependent variable in this study, was classified as "practiced" if the participants performed ≥ 75 min of high-intensity PA weekly, ≥ 150 min of moderate-intensity PA weekly, or a combination of high- and moderate-intensity activity according to the WHO recommendation[12]. Otherwise, MVPA was considered "not practiced." RE was classified as "practiced" if performed ≥ 2 days a week and involved major muscle groups in accordance with WHO recommendation and "not practiced" if performed < 1 day a week. ST was initially classified into < 4 h, between 4 and 6 h, between 6 and 8 h, and ≥ 8 h. For logistic regression, we classified ST into < 8 h and ≥ 8 h because previous studies report that ST > 8 h increases the risk of long-term stroke and cardiovascular disease[33]. This threshold has been widely used in epidemiological studies examining sedentary behavior and health outcomes[34].

General characteristic variables were classified as follows: sex (male or female), age (< 50, 50–59, 60–69, 70–79, or > 80 years), marital status (having a spouse or not), number of household members (1, 2, 3, 4 or more), and economic activity (yes or no). Education level was classified into middle-school graduate or below, high-school graduate, and college graduate or above, and household income was classified as low, low-middle, upper-middle, or upper based on the corresponding quartile. Residential areas were categorized into urban and rural areas based on the administrative region of South Korea where the participants lived[35]. Health insurance was classified into National Health Insurance and Medical Aid.

Body mass index (BMI) was classified into < 18.5 kg/m², 18.5 to < 23.0 kg/m² ², 23.0 to < 25.0 kg/m², and > 25.0 kg/m². Chronic diseases were classified as yes or no based on a doctor's diagnosis of hypertension, diabetes, myocardial infarction and angina, asthma, liver cirrhosis, renal failure, and cancer. Perceived health was classified as good, moderate, or bad. We classified smoking as smoking or non-smoking based on the current smoking status. Alcohol consumption was classified as high-risk drinking if men consumed seven or more drinks and women consumed five or more drinks while drinking more than twice weekly; other drinking behaviors were classified as moderate or non-drinking. Health checkup was classified as yes or no depending on whether a health checkup had been completed in the last 2 years.

Statistical analysis

The National Health and Nutrition Survey was designed using stratified cluster sampling rather than simple random sampling. Based on the sample design of KNHANES, we applied sampling weights to all statistical analyses to generate unbiased estimates representative of the entire Korean population[30,36].

General characteristics, health-related features, whether to practice MVPA, weekly RE frequency, and length of ST were compared according to the presence or absence of a history of stroke. Categorical variables are expressed as frequencies and percentages, and p-values were calculated using the chi-square test. The number of ST, a continuous variable, is expressed as mean, and standard deviation and p-values were determined using the student t-test. The characteristics of SSs were analyzed in descriptive analyses according to MVPA, RE frequency, and ST of ≥ 8 h daily. To ensure clarity in reporting group differences, absolute percentage differences were used to compare proportions. Finally, univariate and multivariate logistic regression analyses were conducted to identify associated factors that could independently predict aerobic physical inactivity (API), inadequate RE, and ST of ≥ 8 h daily as dependent variables, with the characteristics examined in KNHANES as covariates. Additionally, we conducted a sensitivity analysis by adjusting the appropriate PA standard to MVPA for at least 60 min daily, the RE standard to muscle-strengthening activities at least once, and ST standards for more than

six hours a day. Variables having a p-value of < 0.10 in the univariate analysis were included in the multivariate analysis as confounding factors.

All statistical analyses were performed using the statistical package for social sciences (version 26.0; IBM Inc., Armonk, NY, USA) and R statistical software (version 4.1.2; R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at a two-sided p-value < 0.05.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Received: 22 August 2024; Accepted: 2 April 2025
Published online: 09 April 2025

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Author contributions
EL, SK researched literature and conceived the study. EL, HJ, JB were involved in data analysis. EL wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Funding
This study was supported by a grant (2023-ER1006-02) from the Korean Disease Control and Prevention Agency.

Declarations

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-025-97049-5.

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