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ORIGINAL RESEARCH

Long-Term Functional Outcome in Patients With Isolated Thalamic Stroke: The KOSCO Study

Ho Seok Lee, MD, PhD; Min Kyun Sohn, MD, PhD; Jongmin Lee, MD, PhD; Deog Young Kim, MD, PhD; Yong-Il Shin, MD, PhD; Gyung-Jae Oh, MD, PhD; Yang-Soo Lee, MD, PhD; Min Cheol Joo, MD, PhD; So Young Lee, MD, PhD; Min-Keun Song, MD, PhD; Junhee Han, PhD; Jeonghoon Ahn, PhD; Dae Hyun Kim, MD, PhD; Yun-Hee Kim, MD, PhD; Won Hyuk Chang, MD, PhD

BACKGROUND: Information on the long-term prognosis in patients with isolated thalamic stroke is sparse. We report the functional outcomes of patients with thalamic stroke up to 24 months from the KOSCO (Korean Stroke Cohort for Functioning and Rehabilitation) study.

METHODS AND RESULTS: Isolated thalamic stroke was defined as the presence of lesions solely in the thalamus, excluding cases with lesions in other brain parenchyma areas apart from the thalamus, as identified by brain magnetic resonance imaging or computed tomography scans. The Fugl-Meyer Assessment, the Functional Ambulatory Category, the Korean Mini-Mental State Examination, the American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale, and the short version of the Korean Frenchay Aphasia Screening Test were used to assess physical impairment. The Functional Independence Measure and modified Rankin Scale were used to assess functional outcomes. All measurements were conducted up to 24 months poststroke. A total of 297 patients were included, consisting of 235 with ischemic and 62 with hemorrhagic stroke. Except for the Functional Ambulatory Category and Functional Independence Measure, all physical impairments showed significant improvement up to 3 months poststroke ($P<0.001$) and reached a plateau. The Functional Ambulatory Category and Functional Independence Measure scores continued to improve up to 12 months poststroke ($P<0.05$) and reached a plateau. At 7 days poststroke, 47.5% of patients had no disability (modified Rankin Scale score<2), whereas at 24 months poststroke, 76.4% of patients had no significant disability.

CONCLUSIONS: Patients showed rapid recovery from physical impairment up to 3 months poststroke, with additional improvements in ambulatory function and independence observed up to 12 months poststroke. Additionally, relatively favorable long-term functional prognosis at 24 months after onset was demonstrated. These results could provide insights into the proper management regarding functional outcomes of patients with isolated thalamic stroke.

Key Words: functional prognosis ■ long-term outcome ■ recovery pattern ■ stroke ■ thalamus

Although age-adjusted incidence and mortality rates have been decreasing in past decades, stroke remains the third leading cause of death and disability.[1] Moreover, as more patients survive with disabilities after stroke, the global burden of stroke has been increasing.[2,3] Therefore, it is important to

Correspondence to: Won Hyuk Chang, MD, PhD, Department of Physical and Rehabilitation Medicine, Center for Prevention and Rehabilitation, Heart Vascular Stroke Institute, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea.Department of Health Science and Technology, Department of Medical Device Management and Research, SAIHST, Sungkyunkwan University, Seoul, Republic of Korea 81, Irwon-ro, Gangnam-gu, Seoul 06351, Republic of Korea. Email: wh.chang@samsung.com, iamchang@skku.edu Yun-Hee Kim, MD, PhD, Department of Physical and Rehabilitation Medicine, Sungkyunkwan University School of Medicine, Suwon, Republic of Korea 2066, Seobu-ro, Jangan-gu, Suwon-si, Gyeonggi-do 16419, Republic of Korea. Email: yunkim@skku.edu

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CLINICAL PERSPECTIVE

What Is New?

- This study provided long-term functional outcomes and recovery patterns of patients with isolated thalamic stroke, in diverse physical domains.
- Relatively rapid recovery and a favorable long-term functional prognosis of patients with isolated thalamic stroke were demonstrated.

What Are the Clinical Implications?

- Patients with isolated thalamic stroke and clinicians could be provided precise long-term recovery patterns and functional prognosis regarding disabilities, as well as insight for proper management strategies.

Nonstandard Abbreviations and Acronyms

ASHA-NOMS	American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale
FAC	Functional Ambulatory Category
FIM	Functional Independence Measure
FMA	Fugl-Meyer Assessment
HS	hemorrhagic stroke
IS	ischemic stroke
KOSCO	Korean Stroke Cohort for Functioning and Rehabilitation
MMSE	Mini-Mental State Examination
mRS	modified Rankin Scale
short K-FAST	short version of the Korean Frenchay Aphasia Screening Test

accurately understand the long-term disability and functional outcomes of stroke to establish appropriate management and coping strategies.

Overall stroke mortality, disease progress, and long-term functional outcomes are relatively well known from previous studies.[4–6] However, studies on stroke outcomes according to specific locations are lacking. Given that the symptoms of stroke can vary significantly depending on the precise location of the brain lesion, a comprehensive understanding of outcomes for specific stroke types is imperative for their effective management. Notably, there are few studies on isolated thalamic stroke. The thalamus is a complex brain structure containing several nuclei that are associated with various functions, and thalamic stroke generally presents with symptoms such as motor weakness, sensory disturbances, cognitive defects, or language deficits based on specific thalamic vascular lesions.[7,8] Despite these previous reports, the exact physical impairments after thalamic stroke, both ischemic stroke (IS) and hemorrhagic stroke (HS), and long-term functional prognosis are not well recognized. Providing precise information regarding the functional outcomes of isolated thalamic stroke could lead to enhancements in effective management, including rehabilitation, care, and the quality of life for survivors.

Therefore, in this study, we aimed to investigate the long-term functional outcomes, including multifaceted physical impairments and prognosis, of isolated thalamic stroke. The total follow-up period was 24 months after the onset of stroke. Additionally, we evaluated the differences in functional outcomes between the patients with IS and HS. We analyzed data from a multicenter Korean cohort study of patients who experienced a first-ever acute stroke.

METHODS

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Data Collection

The KOSCO (Korean Stroke Cohort for Functioning and Rehabilitation) is a prospective multicentered cohort study of patients with first-time stroke. Data were collected from 9 hospitals in Korea.[9] All the patients provided written informed consent, and the study protocol was approved by the institutional review board of each participating hospital.

This study conducted a retrospective analysis of the KOSCO data up to 24 months after the onset of stroke. Clinical characteristics including demographic information (age, sex, body mass index, and smoking and alcohol history), stroke risk factors[10] (hypertension, diabetes, coronary heart disease, atrial fibrillation, and hyperlipidemia) recorded during admission, comorbidities, and prestroke functional level were documented. Comorbidities were assessed using the combined condition- and age-related score in the Charlson Comorbidity Index.[11] The modified Rankin Scale (mRS) score was used to assess prestroke functional level.[12] National Institutes of Health Stroke Scale[13] and Glasgow Coma Scale[14] scores recorded upon the first arrival to the hospital were used to assess initial IS and HS severity, respectively. After the initial assessment,

National Institutes of Health Stroke Scale was used to assess stroke severity for both patients with IS and with HS.[15] To assess baseline stroke severity, we used National Institutes of Health Stroke Scale at 7 days after stroke onset for both IS and HS. The duration of first hospitalization, records of whether the patients received inpatient rehabilitation therapy, and information for medical complications during the first hospitalization were recorded. The complications included thromboembolic disease, pneumonia, ventilator insufficiency, urinary tract infection, bladder dysfunction, bowel dysfunction, and poststroke central pain. The pathogenesis of each patient was documented by the Trial of Org 10172 in Acute Stroke Treatment classification for IS[16] and previous stroke classification for HS.[17]

The following functional assessments for multiple domains were conducted at 7 days and 3, 6, 12, 18, and 24 months after the onset of stroke: the Fugl-Meyer Assessment (FMA)[18] for motor function, Functional Ambulatory Category (FAC)[19] for ambulatory function, Korean Mini-Mental State Examination (MMSE)[20] for cognitive function, American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale (ASHA-NOMS)[21] for swallowing function, and the short version of the Korean Frenchay Aphasia Screening Test (short K-FAST)[22] for language function. The level of functional independence in the activities of daily living was assessed using Functional Independence Measure (FIM)[23,24] at 3, 6, 12, 18 and 24 months after stroke onset. The degree of disability in patients with stroke was documented using the mRS from 7 days to 24 months after the onset of stroke, to assess their prognosis. Additionally, the generic health-related quality of life was evaluated using Euro Quality of Life 5-Dimension-3L[25] at 24 months after the onset of stroke, to assess the subjective quality of life of patients based on functional prognosis.

Selection of KOSCO Participants With Isolated Thalamic Stroke, Without Premorbid Functional Impairment

Between August 2012 and May 2015, in 9 different hospitals in Korea, a total of 10 636 patients (8210 [77.2%] with IS and 2426 [22.8%] with HS) with first-time stroke were screened. In this study, we defined isolated thalamic stroke as the presence of lesions solely in the thalamus, excluding cases with lesions in other brain parenchyma areas apart from the thalamus, as identified by brain magnetic resonance imaging or computed tomography scans. According to this definition, 672 (6.3%) out of 10 636 patients with stroke (486 [5.9%] out of 8210 patients with IS and 186 [7.7%] out of 2426 patients with HS) were classified as having isolated thalamic stroke. Of the 672 patients with isolated thalamic stroke, 8 patients (1.2%) died before deciding to participate, and 134 patients (20.0%) declined or withdrew from participating in the KOSCO study. To focus solely on the impact of isolated thalamic stroke for long-term functional outcomes in this study, 92 patients with premorbid functional impairment (mRS score≥2) were excluded. Out of the remaining 438 patients, 13 patients (3.0%) died and 128 patients (29.2%) were lost to follow-up at 24 months after stroke onset. Finally, a total of 297 patients with isolated thalamic stroke were included in this analysis, comprising 235 patients with IS (79.1%) and 62 patients with HS (20.9%) (Figure 1).

Statistical Analysis

Categorical variables were presented as numbers of frequencies and percentages. Numerical variables were summarized as means and SDs. The differences between the patients with IS and HS were analyzed using an independent *t* test and chi-square test for numerical and categorical variables, respectively. A paired *t* test and a Wilcoxon signed-rank test with Bonferroni correction were used to analyze differences in measurements between time points after stroke onset for numerical and categorical measurements, respectively.

To evaluate prognostic factors associated with the degree of disability at 24 months after the onset of stroke, multivariable logistic regression analysis was performed with factors that were found to be statistically significant in univariable regression analysis.

A statistically significant *P* value was set at <0.05 for all the analyses performed in this study. Statistical analyses were performed using SPSS version 25.0 for Windows (SPSS Inc., Chicago, IL). Missing data were present at each follow-up time point for patients lost to follow-up. We excluded these missing data from the analysis, as demographics and characteristics did not exhibit statistical differences between respondents and those who were lost to follow-up. The details of missing data are provided in Table S1.

RESULTS

Patient Characteristics

The mean age (SD) of all the patients with isolated thalamic stroke was 65.3±11.7, and there was no significant difference in age between patients with IS and HS (65.5±11.6 in IS and 64.7±12.0 in HS). Among the demographic and clinical characteristics, there was a significant difference in several parameters between patients with IS and HS. These included body mass index (24.6±3.5 in IS and 23.6±3.4 in HS), prestroke functional level measured by mRS score (0.2±0.4 in IS and 0.1±0.3 in HS), baseline severity at 7 days measured by National Institutes of Health Stroke Scale score (1.6±2.5 in IS and 8.1±8.4 in HS), duration of first

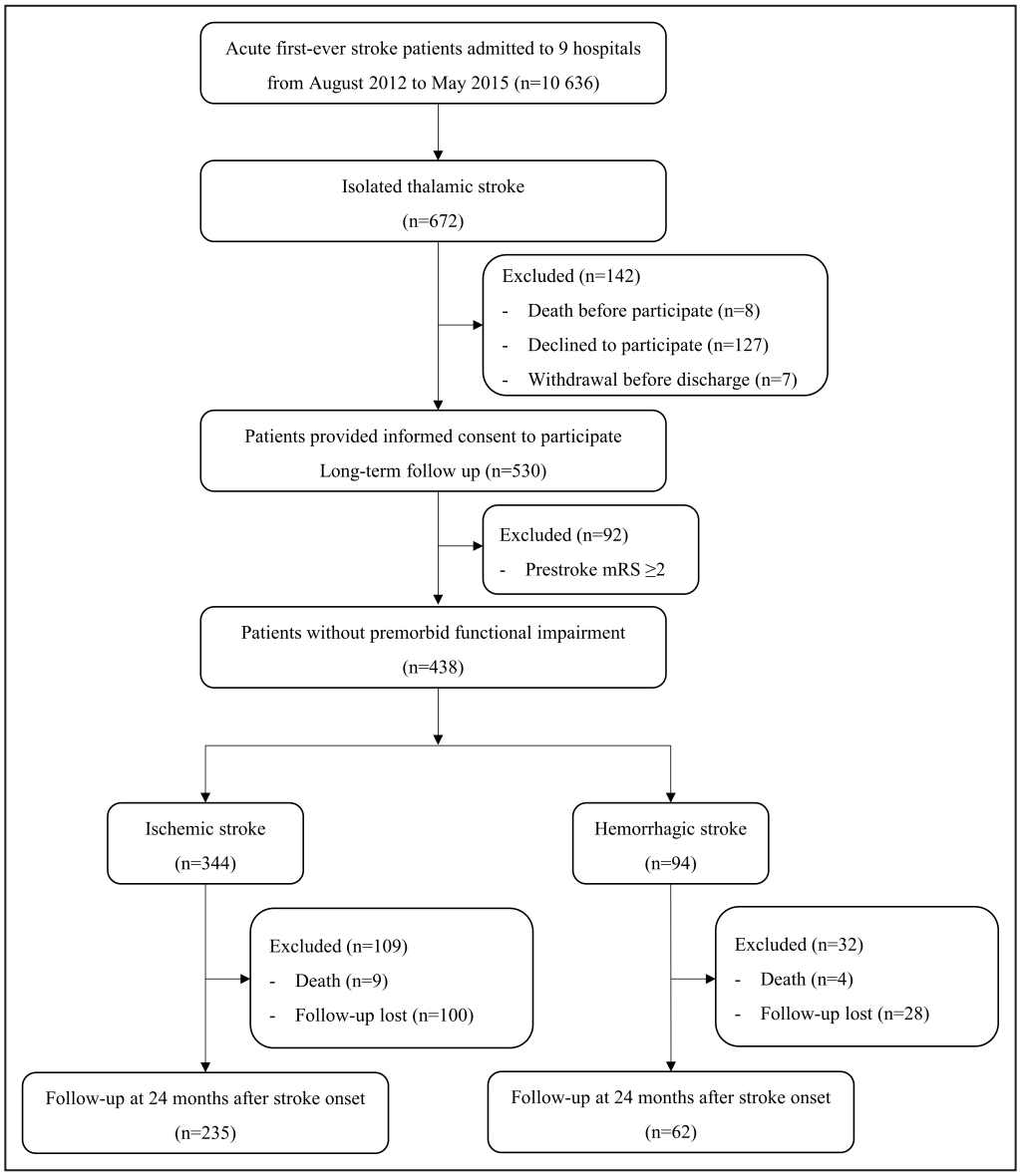

Figure 1. Flow chart of the study participants.
mRS indicates modified Rankin Scale.

hospitalization (9.6±12.4 in IS and 32.5±24.5 in HS), and receiving inpatient rehabilitation (80 [34.0%] in IS and 35 [56.5%] in HS). Additionally, medical complications including pneumonia (2 [0.9%] in IS and 4 [6.5%] in HS), ventilator insufficiency (0 in IS and 4 [6.5%] in HS), and bladder dysfunction (6 [2.6%] in IS and 9 [14.5%] in HS) were significantly more prevalent in patients with HS. There was no significant difference in the prevalence of poststroke central pain between the patients with IS and HS (5 [2.1%] in IS and 1 [1.6%] in HS). The primary causes were small vessel occlusion and hypertension-related small vessel disease for thalamic IS and HS, respectively. The results of demographic and clinical characteristics are shown in Table 1.

Multifaceted Physical Impairments From 7 Days to 24 Months After Stroke Onset

Each physical impairment in all participants analyzed in this study showed a similar pattern with improvements from 7 days to 3 months after stroke onset and reaching a plateau thereafter, except for ambulatory function. The mean FMA score (SD) significantly improved from 87.1 (26.6) at 7 days to 92.4 (20.1) at 3 months after stroke onset and plateaued thereafter. The mean Korean MMSE score (SD) significantly improved from 7 days (23.1 [8.3]) to 3 months (25.2 [7.0]) after stroke and reached a plateau. The mean ASHA-NOMS score (SD) improved from 7 days (6.4 [1.5]) to 3 months (6.7 [1.2]) after stroke and showed

Table 1. Demographic and Clinical Characteristics of the Participants

Demographic and clinical characteristics	Frequency (percentage) or mean±SD		
	Total (n=297)	Ischemic stroke (n=235)	Hemorrhagic stroke (n=62)
Lesion side			
Right	154 (51.9%)	125 (53.2%)	29 (46.8%)
Left	135 (45.5%)	102 (43.4%)	33 (53.2%)
Bilateral	8 (2.7%)	8 (3.4%)	0
Age, y	65.3±11.7	65.5±11.6	64.7±12.0
Young (<65)	134 (45.1%)	104 (44.3%)	30 (48.4%)
Old (≥65)	163 (54.9%)	131 (55.7%)	32 (51.6%)
Sex			
Male	167 (56.2%)	129 (54.9%)	38 (61.3%)
Female	130 (43.8%)	106 (45.1%)	24 (38.7%)
Body mass index	24.4±3.5	24.6±3.5	23.6±3.4*
Smoking, current	70 (23.6%)	58 (24.7%)	12 (19.4%)
Alcohol, current	115 (38.7%)	85 (36.2%)	30 (48.4%)
Risk factors			
Hypertension, yes	165 (55.6%)	127 (54.0%)	38 (61.3%)
Diabetes, yes	77 (25.9%)	63 (26.8%)	14 (22.6%)
Coronary heart disease, yes	24 (8.1%)	20 (8.5%)	4 (6.5%)
Atrial fibrillation, yes	14 (4.7%)	12 (5.1%)	2 (3.2%)
Hyperlipidemia, yes	56 (18.9%)	44 (18.7%)	12 (19.4%)
Combined condition- and age-related score in the Charlson Comorbidity Index	5.3±1.5	5.3±1.5	5.3±1.8
Prestroke modified Rankin Scale score	0.2±0.4	0.2±0.4	0.1±0.3*
Initial severity			
Initial NIHSS score	3.0±3.8	3.0±3.8	
Initial Glasgow Coma Scale score	13.4±3.2		13.4±3.2
Baseline severity, NIHSS at 7 d	3.0±5.2	1.6±2.5	8.1±8.4†
Duration of hospitalization, d	14.4±18.2	9.6±12.4	32.5±24.5†
Inpatient rehabilitation, yes	115 (38.7%)	91 (34.0%)	35 (56.5%)*
Complications during hospitalization			
Thromboembolic disease, yes	3 (1.0%)	1 (0.4%)	2 (3.2%)
Pneumonia, yes	6 (2.0%)	2 (0.9%)	4 (6.5%)*
Ventilatory insufficiency, yes	4 (1.4%)	0	4 (6.5%)*
Urinary tract infection, yes	5 (1.7%)	2 (0.9%)	3 (4.8%)
Bladder dysfunction, yes	15 (5.1%)	6 (2.6%)	9 (14.5%)*
Bowel dysfunction, yes	14 (4.7%)	8 (3.4%)	6 (9.7%)
Poststroke central pain, yes	6 (2.0%)	5 (2.1%)	1 (1.6%)
Cause			
Ischemic stroke			
Large artery atherosclerosis		76 (32.3%)	
Small vessel occlusion		107 (45.5%)	
Cardioembolism		19 (8.1%)	
Other determined		19 (8.1%)	
Undetermined		14 (6.0%)	
Hemorrhagic stroke			
Hypertension-related small vessel disease			36 (58.1%)
Bleeding diathesis			1 (1.6%)

(*Continued*)

Table 1. Continued

Demographic and clinical characteristics	Frequency (percentage) or mean±SD		
	Total (n=297)	Ischemic stroke (n=235)	Hemorrhagic stroke (n=62)
Vascular malformation			1 (1.6%)
Other determined			2 (3.2%)
Unclassifiable			1 (1.6%)
Unknown			21 (33.9%)

NIHSS indicates National Institutes of Health Stroke Scale.
*P<0.05.
†P<0.001, compared with ischemic stroke patients using independent t test and chi-square test for numerical variables and categorical variables, respectively.

no significant improvement thereafter. Similarly, the mean short K-FAST score (SD) also improved from 14.8 (5.2) at 7 days to 16.6 (3.9) at 3 months after stroke and plateaued thereafter. The mean FAC score (SD) significantly improved from 7 days (3.5 [1.7]) to 3 months (4.3 [1.4]) after stroke. Moreover, there was a further improvement in ambulatory function from 3 months to 12 months after stroke onset, with the mean FAC score (SD) reaching 4.5 (1.2). Afterward, the ambulatory function reached a plateau. The functional level of independence, measured by the mean FIM score (SD), exhibited a significant improvement from 3 months (114.4 [22.9]) to 12 months (116.2 [22.7]) after the onset of stroke and then reached a plateau (Figure 2 and Table S2).

Subgroup Analyses of Functional Outcomes

Subgroup analysis revealed that all functional outcomes of multiple domains were significantly better in patients with IS than in patients with HS at every follow-up time point (Figure 2 and Table S2).

In patients with IS, the mean scores (SD) for FMA, Korean MMSE, ASHA-NOMS, and short K-FAST demonstrated a significant improvement from 7 days (94.4 [16.5], 24.8 [6.7], 6.7 [1.0], and 15.8 [4.3], respectively) to 3 months (96.7 [12.1], 26.1 [5.9], 6.8 [0.8], and 17.0 [3.5], respectively) after the stroke onset and then plateaued. The mean FAC score (SD) showed a significant improvement from 7 days (4.0 [1.3]) to 3 months (4.6 [0.9]), and continued to improve up to 24 months (4.8 [0.8]) after stroke onset. The mean FIM score (SD) exhibited a significant improvement from 3 months (118.9 [16.7]) to 18 months (121.1 [15.7]) after stroke onset.

In patients with HS, the mean scores (SD) for FMA, FAC, Korean MMSE, ASHA-NOMS, and short K-FAST showed significant improvement from 7 days (59.5 [37.4], 1.5 [1.8], 16.5 [10.2], 5.3 [2.4], and 10.3 [6.6], respectively) to 3 months (75.6 [32.8], 3.2 [2.1], 21.6 [9.7], 6.0 [2.0], and 15.1 [5.0], respectively) after stroke onset and then plateaued. However, the mean FIM score (SD) did not show any significant differences from the beginning of the assessment at 3 months after stroke onset.

Prognosis of an Isolated Thalamic Stroke at 24 Months After the Onset of Stroke

The degree of disability measured by the mean mRS score (SD) significantly improved from 7 days (2.0 [1.5]) to 3 months (1.3 [1.3]) and from 3 months to 6 months (1.1 [1.3]) after stroke and reached a plateau thereafter. Patients with IS also reached a plateau at 6 months after the onset of stroke (1.6 [1.1] at 7 days, 1.0 [1.0] at 3 months, and 0.9 [1.0] at 6 months after stroke). Patients with HS reached a plateau at 3 months after the onset of stroke (3.8 [1.4] at 7 days and 2.5 [1.6] at 3 months after stroke). At 24 months after the stroke, the mean mRS score (SD) was 1.1 (1.3) for all patients, 0.8 (1.0) for patients with IS, and 2.2 (1.7) for patients with HS patients (Table S1).

At 7 days after stroke, 133 (47.5%) patients showed no significant disability (mRS score<2), and 147 (52.5%) patients had some level of disability (mRS score≥2). At 24 months after stroke, 227 (76.4%) patients showed no significant disability, and 70 (23.6%) patients had some level of disability. In patients with IS, 93 (41.9%) patients at 7 days and 34 (14.5%) patients at 24 months had some level of disability. In patients with HS, 54 (93.1%) patients and 36 (58.1%) patients demonstrated some level of disability at 7 days and 24 months after stroke, respectively (Figure 3 and Table S3).

In Figure 4 and Table S4, the percentage of participants reporting any problems in each Euro Quality of Life 5-Dimension dimension at 24 months after stroke onset is presented. Among the Euro Quality of Life 5-Dimension dimensions, the pain/discomfort category was found to be the most commonly reported problem in all patients, regardless of stroke type or presence of disability. In patients with mRS score≥2, mobility and usual activity categories were the next frequently reported problems, whereas the anxiety/depression category was the least commonly reported problem. In patients with no significant disability, patients with IS and HS showed a different pattern. In patients with HS, the mobility and usual activity categories were the next

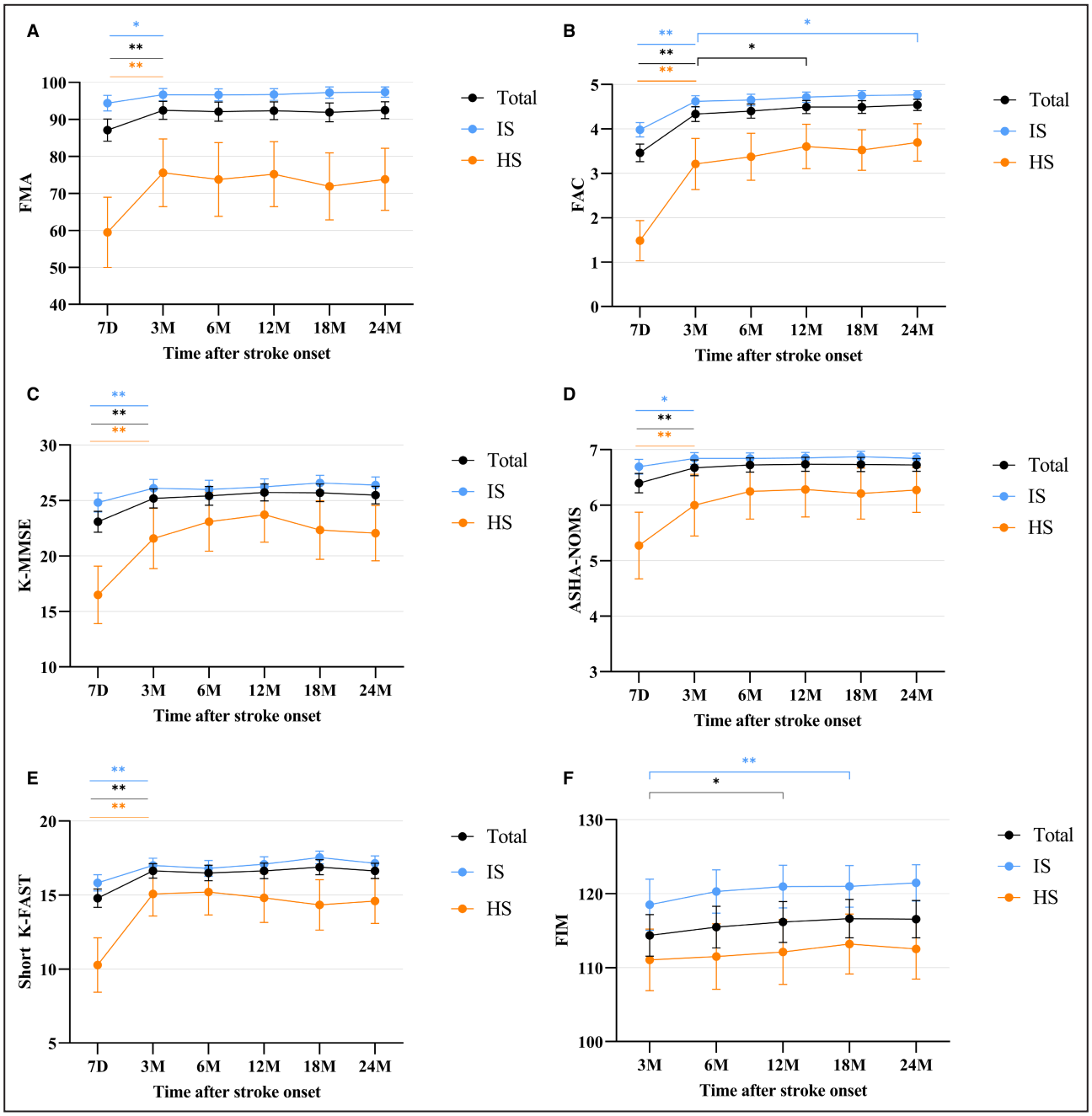

Figure 2. Multifaceted physical impairments at each time point after stroke onset.
A, Fugl-Meyer Assessment. **B**, Functional Ambulation Category. **C**, Korean Mini-Mental State Examination. **D**, American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale. **E**, Short version of the Korean Frenchay Aphasia Screening Test. **F**, Functional Independence Measure. The *x* axis represents the time point after stroke onset, and the *y* axis represents functional assessment scores. All data are presented on the graph as mean values with 95% CIs. **P*<0.05, ***P*<0.001, compared between each time point using paired *t* test and Wilcoxon signed-rank test with Bonferroni correction for numerical and categorical measurements, respectively. ASHA-NOMS indicates American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale; D, days; FAC, Functional Ambulation Category; FIM, Functional Independence Measure; FMA, Fugl-Meyer Assessment; HS, hemorrhagic stroke; IS, ischemic stroke; K-MMSE, Korean Mini-Mental State Examination; M, months; and Short K-FAST, Short Korean version of the Frenchay Aphasia Screening Test.

commonly reported problems, similar to patients with disabilities. However, in patients with IS, the anxiety/depression category was reported as the second most common problem.

In the multivariable regression analysis, using significant factors identified from the univariable analyses, age and FMA score at 7 days after stroke were found to be significantly associated with the degree

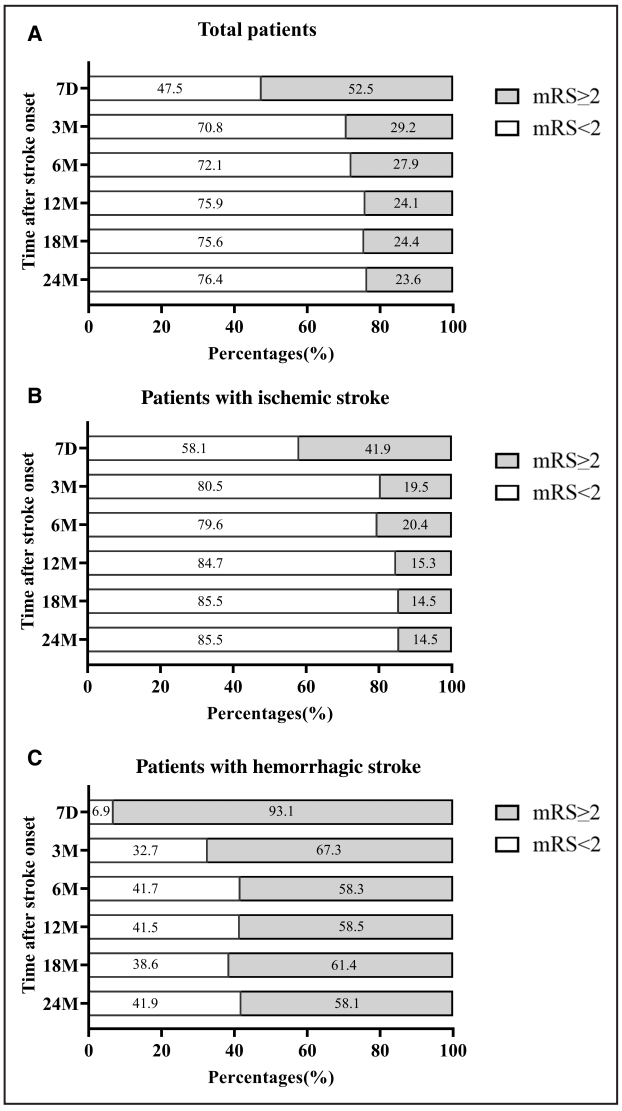

Figure 3. The mRS distribution at each time point after stroke onset.
A, mRS scores of total patients. **B**, mRS scores of patients with hemorrhagic stroke. **C**, mRS scores of patients with ischemic stroke. mRS indicates modified Rankin Scale.

of disability measured by the mRS at 24 months after stroke (Table 2).

DISCUSSION

This study revealed the long-term functional outcome for various physical domains in patients with isolated thalamic stroke. Previous studies have reported that functions in patients with stroke tend to reach a plateau after 6 to 18 months following stroke onset.[6,26,27] However, our study demonstrated that most of the physical impairments measured in patients with thalamic stroke showed significant improvement and reached a plateau at 3 months after stroke onset, which is faster than that reported in patients with general stroke in the previous studies.

In previous studies, the clinical presentations of isolated thalamic stroke have been well documented.[8,28] Notably, one previous study reported the motor deficits of both patients with IS and HS. Specifically, it demonstrated that 89% of IS and 95% of HS patients had motor weakness.[29] However, other studies only reported the proportions of patients with thalamic stroke exhibiting functional deficits.[28,30] In this study, we demonstrated precise values for functional outcomes and recovery patterns in patients with isolated thalamic stroke. At 3 months after stroke onset, when most of the physical domains reached a plateau, participants demonstrated a mean FMA score of 92.4, mean FAC score of 4.3, mean MMSE score of 25.2, mean ASHA-NOMS score of 6.7, and mean short K-FAST score of 16.6. For the functional level of independence, the mean FIM score was 114.4. The ambulatory function further improved up to 12 months after stroke onset (the mean FAC score 4.5), as well as the function level of independence (the mean FIM score 116.2). Therefore, patients with isolated thalamic stroke may be provided with information that their disabilities observed during the acute phase are likely to recover rather rapidly, and further improvements in function could be achieved by focusing on motor and ambulatory functions.

The level of functional outcomes in isolated thalamic stroke significantly differed between patients with IS and HS. Each functional domain showed a greater recovery rate in patients with HS from 7 days to 3 months after stroke onset, although the mean score was lower than that of patients with IS. Patients with HS exhibited significantly lower functional levels in every domain throughout the entire follow-up period than that of patients with IS. Previous studies comparing the outcomes between patients with IS and HS with isolated thalamic stroke are limited. One study reported that patients with thalamic HS exhibited more severe deficits than patients with IS; however, they had concomitant intraventricular hemorrhages.[29] Additionally, previous studies have documented that thalamic infarction could impair cognitive functions[31,32] and another recent study has shown the impact of thalamic HS on cognitive function.[33] However, no studies have documented the difference in cognitive function between patients with IS and HS after stroke onset. In this study, we documented that thalamic HS has a more significant influence on diverse functional domains than thalamic IS. Therefore, it is important to recognize that intensive rehabilitation is especially critical for patients with thalamic HS to achieve maximal potential recovery within first 3 months after stroke onset. Furthermore, given that all functional domains were less functional in patients with thalamic HS compared with patients with IS, it is imperative to accurately address the remaining

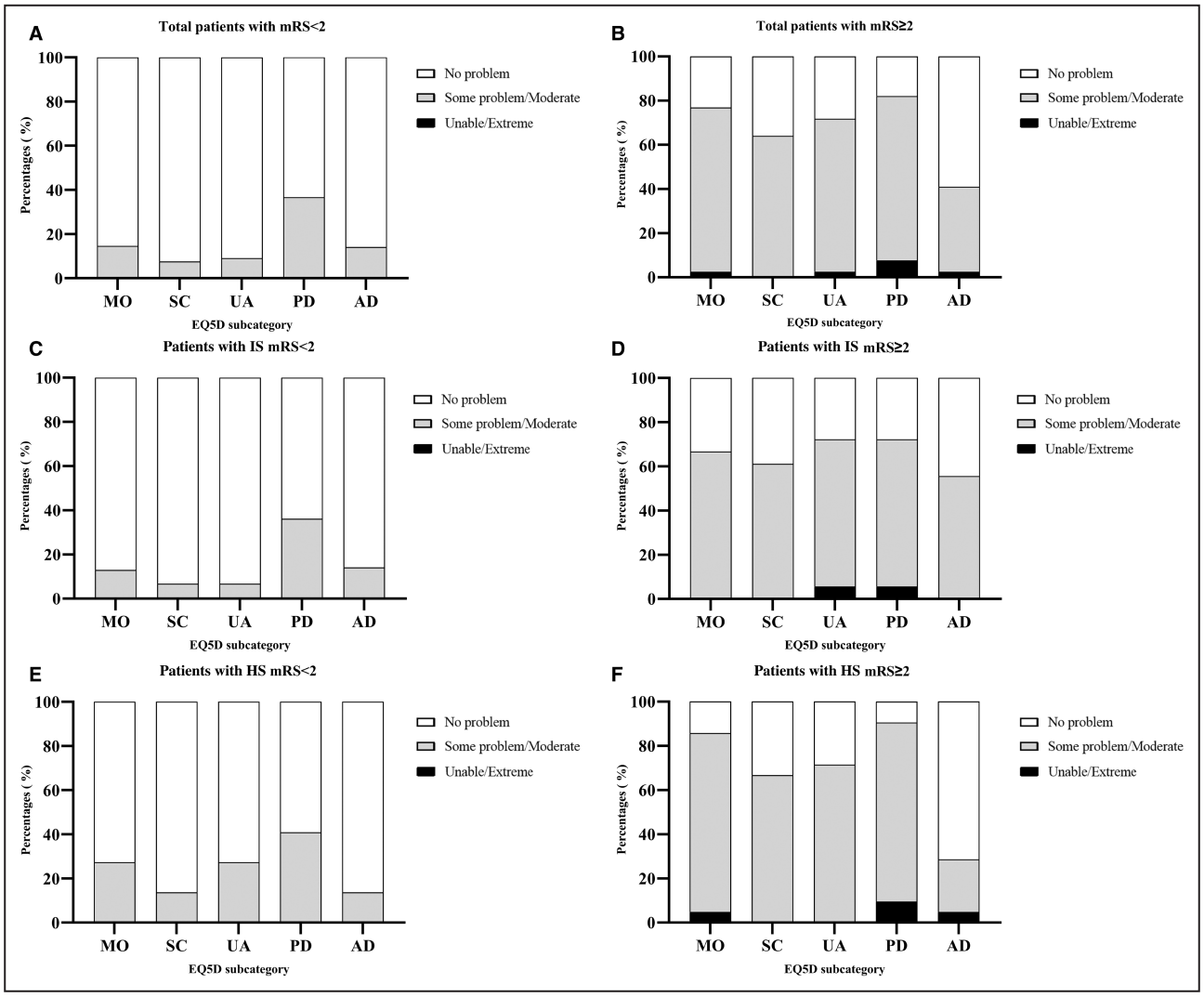

Figure 4. The EQ-5D subcategory at 24 months after stroke onset.
A, EQ-5D of all patients with mRS score<2. **B**, EQ-5D of all patients with mRS score≥2. **C**, EQ-5D of patients with IS with mRS score<2. **D**, EQ-5D of patients with IS with mRS≥2. **E**, EQ-5D of patients with HS with mRS score<2. **F**, EQ-5D of patients with HS with mRS score≥2. AD indicates anxiety/depression; EQ-5D, Euro Quality of Life 5 dimension; HS, hemorrhagic stroke; IS, ischemic stroke; MO, mobility; mRS indicates modified Rankin Scale; PD, pain/discomfort; SC, self-care; and UA, usual activities.

functional disabilities in patients with HS and provide the appropriate rehabilitation management they require.

In addition, we revealed that the functional prognosis of patients with isolated thalamic stroke as measured by the mRS. In this study, 23.6% of all patients with thalamic stroke who were previously independent before the onset of stroke reported some level of disability (mRS score≥2) at 24 months after stroke. In subgroup analysis, 14.5% of patients with IS and 58.1% of patients with HS reported dependency. No previous study has demonstrated the prognosis of a thalamic stroke at 24 months after stroke. A recent study demonstrated the outcome of patients with IS and HS with isolated thalamic stroke at 3 months after stroke. It reported that 19 out of 22 patients (86.4%) with IS and 7 out of 12 patients (58.3%) with HS showed mRS score≤2.[34] We report corresponding portions, 92.2% and 53.9% in patients with IS and HS, respectively. In addition to isolated thalamus, other previous studies have documented the prognosis in terms of dependency in patients with stroke in general. Ullberg et al demonstrated 28.3% of 35 064 patients with stroke who were independent before stroke onset stated dependency (mRS score≥3) at 12 months after stroke.[35] Sennfalt et al documented 33.2% of 13 460 patients with stroke (32.4% among 12 105 patients with IS and 40.9% among 1355 patients with HS) reported dependency at 12 months after stroke onset.[5] Appelros et al reported that 153 (60.5%) out of 253 patients were classified mRS score≥2 at 12 months after stroke.[36] In this study, comparing at the same 12 months after

Table 2. Logistic Regression Analyses for Prognostic Factors of the Degree of Disability at 24 Months After Stroke

	Univariable regression analysis			Multivariable regression analysis		
	Odds ratio	95% CI	*P* value	Odds ratio	95% CI	*P* value
Age	1.070	1.040–1.102	<0.001	1.065	1.018–1.114	0.006
Stroke type, hemorrhagic stroke	8.186	4.384–15.282	<0.001	2.576	0.907–7.321	0.070
Sex, male	1.289	0.751–2.211	0.400			
Body mass index	0.924	0.851–1.003	0.060			
Smoking, current	0.603	0.302–1.205	0.200			
Alcohol, current	0.660	0.373–1.170	0.200			
Risk factors						
Hypertension, yes	0.575	0.328–1.007	0.050			
Diabetes, yes	0.764	0.421–1.387	0.400			
Coronary heart disease, yes	0.919	0.348–2.422	0.900			
Atrial fibrillation, yes	1.137	0.307–4.220	0.900			
Hyperlipidemia, yes	1.525	0.723–3.217	0.300			
Combined condition- and age-related score in the Charlson Comorbidity Index	1.319	1.101–1.580	0.003	1.164	0.913–1.485	0.200
Prestroke modified Rankin Scale score	0.677	0.330–1.392	0.300			
Duration of hospitalization	1.054	1.036–1.073	<0.001	1.005	0.978–1.033	0.700
Baseline severity, National Institutes of Health Stroke Scale score at 7 d	1.419	1.270–1.585	<0.001	0.943	0.776–1.146	0.600
Inpatient rehabilitation	0.400	0.231–0.692	0.001	1.097	0.477–2.524	0.800
Functional level at 7 d						
Fugl-Meyer Assessment	0.951	0.937–0.965	<0.001	0.970	0.943–0.998	0.030
Functional Ambulation Category	0.485	0.406–0.580	<0.001	0.875	0.631–1.213	0.400
Korean Mini-Mental State Examination	0.856	0.820–0.893	<0.001	0.954	0.872–1.044	0.300
American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale	0.481	0.371–0.624	<0.001	1.093	0.745–1.604	0.700
Short Korean version of the Frenchay Aphasia Screening Test	0.806	0.756–0.859	<0.001	0.940	0.836–1.057	0.300

ASHA-NOMS indicates American Speech-Language-Hearing Association National Outcome Measurement System Swallowing Scale; CCAS, combined condition- and aged-related score in the Charlson Comorbidity Index; FAC, Functional Ambulation Category; FMA, Fugl-Meyer Assessment; K-MMSE, Korean Mini-Mental State Examination; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; and Short K-FAST, Short Korean version of the Frenchay Aphasia Screening Test.

stroke onset as the previous studies, we report that 24.1% of all patients with thalamic stroke, 15.3% of patients with IS, and 58.5% of patients with HS had some level of disability. These results may imply that in isolated thalamic stroke, all patients and patients with IS exhibited a better prognosis, whereas patients with HS experienced greater rates of disability compared with patients with general stroke.

The Euro Quality of Life 5-Dimension presentation demonstrated that pain/discomfort was the most frequently reported problem in patients with thalamic stroke at 24 months after stroke onset. Although these data were not statistically analyzed, these findings are consistent with well-known sensory discomfort reported in patients with thalamic stroke. Furthermore, in patients who reported dependency, mobility and usual activities were found to be the next most frequent problems in patients with thalamic stroke. These findings imply that motor function is an important concern for disability in patients with isolated thalamic stroke. However, in patients with IS who were independent at 24 months after stroke onset, their second problem was anxiety/depression. These results suggest that sensory and emotional problems should be the focus in patients with thalamic IS without disabilities.

Several previous studies in patients with stroke reported that age, initial stroke severity, duration of hospitalization, functional level at discharge, and comorbidities were commonly associated with dependency after stroke.[37–40] In this study, age and FMA score were identified as significant factors associated with disability at 24 months after isolated thalamic

stroke. Therefore, it is important to properly assess and manage motor function in patients with thalamic stroke to achieve favorable outcomes.

The strength of this study is that it was a large, multicentered study assessing the functional outcomes of various physical domains in patients with isolated thalamic stroke. Furthermore, we investigated the functional outcomes more precisely and categorized them by stroke type. This study has some limitations. First, we did not obtain information about thalamic vascular territories. As thalamic stroke presentations can vary depending on the affected vascular territories, future studies should analyze the differences in outcomes based on specific vascular territories. Second, as these data were collected from the KOSCO cohort study, precise measurement of sensory disturbance was lacking. Third, missing data were present at each time point during the follow-up period. Lastly, as this study was a retrospective analysis of the KOSCO study, we did not evaluate cognitive functions more precisely other than using MMSE.

CONCLUSIONS

In conclusion, this study demonstrated recovery patterns of diverse functional outcomes in patients with isolated thalamic stroke. The long-term prognosis of isolated thalamic stroke is relatively favorable, with motor function being the main problem in patients with disability. Furthermore, patients with HS tend to have poor prognosis. This study provides valuable information for the assessment and proper management of functional outcomes of patients with isolated thalamic stroke.

ARTICLE INFORMATION

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Affiliations

Department of Physical and Rehabilitation Medicine, Center for Prevention and Rehabilitation, Heart Vascular Stroke Institute, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea (H.S.L., D.H.K., W.H.C.); Department of Rehabilitation Medicine, College of Medicine, Chungnam National University, Daejeon, Republic of Korea (M.K.S.); Department of Rehabilitation Medicine, Konkuk University School of Medicine, Seoul, Republic of Korea (J.L.); Department and Research Institute of Rehabilitation Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea (D.Y.K.); Department of Rehabilitation Medicine, Pusan National University School of Medicine, Pusan National University Yangsan Hospital, Yangsan, Republic of Korea (Y-I.S.); Department of Preventive Medicine, Wonkwang University, School of Medicine, Iksan, Republic of Korea (G-J.O.); Department of Rehabilitation Medicine, School of Medicine, Kyungpook National University, Kyungpook National University Hospital, Daegu, Republic of Korea (Y-S.L.); Department of Rehabilitation Medicine, Wonkwang University School of Medicine, Iksan, Republic of Korea (M.C.J.); Department of Rehabilitation Medicine, Jeju National University Hospital, Jeju National University School of Medicine, Jeju City, Republic of Korea (S.Y.L.); Department of Physical and Rehabilitation Medicine, Chonnam National University Medical School, Gwangju, Republic of Korea (M-K.S.); Department of Statistics, Hallym University, Chuncheon, Republic of Korea (J.H.); Department of Health Convergence, Ewha Womans University, Seoul, Republic of Korea (J.A.); Department of Physical and Rehabilitation Medicine, Sungkyunkwan University School of Medicine, Suwon, Republic of Korea (Y-H.K.); and Department of Health Science and Technology, Department of Medical Device Management and Research, Department of Digital Healthcare, SAIHST, Sungkyunkwan University, Seoul, Republic of Korea (W.H.C.).

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Supplemental Material

Tables S1–S4.

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