Aims and Scope

Annals of Rehabilitation Medicine (ARM) is the official journal of the Korean Academy of Rehabilitation Medicine. It is an international, peer-reviewed open access journal, which aims to be a global leader in sharing up-to-date knowledge dedicated to the advancement of care and enhancing the function and quality of life of persons with various disabilities and chronic illnesses. As the official journal of one of the largest societies of rehabilitation medicine in Asia and Oceania, nearly 8,000 physiatrists receive this journal every two months as a member benefit. This journal is endorsed by the International Society of Physical and Rehabilitation Medicine (ISPRM) and the Asia-Pacific Society of Physical and Rehabilitation Medicine (AOSPRM). International members comprise approximately half the editorial board and conduct peer-reviews of submitted manuscripts.

The journal encompasses all aspects of physical medicine and rehabilitation, including clinical practice, experimental and applied research, and education. Research areas covered by this journal include rehabilitation of brain disorders and spinal cord injury; electrodiagnosis; musculoskeletal disorders and pain; pediatric, geriatric, cardiopulmonary, sports, cancer; cognitive, and robotic rehabilitation; neuromodulation; orthotics and prosthetics; physical modalities; clinical trials; quality of life issues; and basic research, as well as other emerging fields in rehabilitation medicine.

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Physiatrists deal with the evaluation, diagnosis and nonsurgical management of neuromusculoskeletal conditions, of which shoulder pain (such as rotator cuff spectrum diseases, frozen shoulder, degenerative arthritis, instability, and rheumatic diseases) is one of the common manifestations. Outcome measures for shoulder care included pain severity, range of motion, and patient-reported outcome measures (PROMs). In this editorial, I would like to comment on some issues regarding PROMs applied to shoulder diseases and recommend options for appropriate PROMs in Korean clinical settings.

There are numerous PROMs with more than 30 different tools for measuring the symptoms and functional states of patients with shoulder diseases [1-4]. Validated legacy PROMs commonly refer to Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and its Short Version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society Standardized Shoulder Assessment Form, Constant (Murry) Score (CS), Simple Shoulder Test, Oxford Shoulder Score, and Western Ontario Rotator Cuff index (WORC) [5]. Previous articles summarized the psychometric properties of legacy PROMs for shoulder diseases [1,2,6]. While these instruments have an overall high quality of psychometric properties, respondent and administrative burdens and ceiling/floor effects have been reported in some PROMs such as ASES and DASH [6].

Most PROMs were developed in English. The preferred PROMs tend to differ depending on the continent because of the historical requirements and availability of the translated version [7]. A recent survey reported that ASES was most commonly used in articles originating from North America and Asia, while it was CS from Europe [7]. Although there are few reports on the transcultural adaptation validation of the ASES in Asia, the fact that many studies using the ASES have been published indicates that it involves a transcultural adaptation issue [8-10]. As far as my knowledge, validity studies on the Korean versions of the SPADI and DASH have been conducted, but there is no validation of the Korean versions of other commonly used evaluation tools, such as the ASES, CS, and WORC [11]. A transcultural adaptation procedure from the English version to the Korean version for major PROMs and a comparative analysis of the psychometric properties of the Korean and original versions are needed.

Currently, there is no consensus regarding the recommended PROMs for specific shoulder diseases. A recent study revealed that ASES was most commonly used for rotator cuff and subacromial pathology, followed by DASH and SPADI, while the use of SPADI is overwhelming for
shoulder stiffness, calcific tendinitis, and nonspecific shoulder pain [12]. Moreover, a recent study demonstrated that the SPADI can be used as a shoulder-specific PROMs in patients with rotator cuff tears because of its strong reliability and excellent discriminatory properties [13]. Considering the presence of the Korean version and good evidence in support of its high-quality psychometric properties, the SPADI can be recommended for monitoring common shoulder diseases such as rotator cuff pathology and shoulder stiffness in Korean clinical practice.

The SPADI was designed to evaluate the degree of shoulder pain and discomfort in performing activities of daily living by the patients themselves, without clinician components. The original version was developed by a panel of rheumatologists and physical therapists and was published in 1991 [14]. Because of this background, SPADI still tends to be preferred in the field of rheumatology and rehabilitation medicine. It has 13 items, with 5 items for pain and 8 items for disability. In the original version, items were rated using a visual analog scale; however, in the more recent version, each item used an 11-point numerical rating scale (0–10) (Table 1) [14,15]. SPADI takes 2–3 minutes to complete. The SPADI total score is the mean of the pain and disability sub-scores. SPADI has been shown to have excellent internal reliability/consistency (Cronbach’s alpha=0.86–0.96) and test-retest reliability (intra-class correlation coefficient=0.84–0.95) [2,6]. SPADI total score correlated well with the ASES score, although there was a low correlation between the SPADI total score and the Short Form 36. However, some disability items (items 4, 7, and 8) showed unsuitable criterion validity [6]. Disability items included only one item to assess overhead words or heavy use. Therefore, the SPADI could have a ceiling effect because it is difficult to accurately evaluate activities that require high shoulder function. A previous study reported that the minimum clinically important difference (MCID) of 13.2 was smaller than the minimally detectable change (MDC) of 18.1%; thus, a change in the MDC is necessary to be confident in the MCID (Table 1) [16].

In conclusion, I recommend the SPADI as a shoulder-specific PROM in patients with shoulder stiffness, rotator cuff spectrum disease, and nonspecific shoulder pain, given the overall psychometric properties and availability of the Korean-language

### Table 1. SPADI items, practical application and psychometric information

<table>
<thead>
<tr>
<th>1. SPADI items</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pain scale (5 items) (0=no pain, 10=the worst pain imaginable)</strong></td>
<td><strong>Disability scale (8 items) (0=no disability, 10=unable to perform)</strong></td>
</tr>
<tr>
<td>(1) At its worst?</td>
<td>(1) Washing your hair?</td>
</tr>
<tr>
<td>(2) When lying on the involved side?</td>
<td>(2) Washing your back?</td>
</tr>
<tr>
<td>(3) Reaching for something on a high shelf?</td>
<td>(3) Putting on an undershirt or jumper?</td>
</tr>
<tr>
<td>(4) Touching the back of your neck?</td>
<td>(4) Putting on a shirt that buttons down the front?</td>
</tr>
<tr>
<td>(5) Pushing with the involved arm?</td>
<td>(5) Putting on your pants?</td>
</tr>
<tr>
<td>Total pain score: ______/50×100= %</td>
<td>(6) Placing an object on a high shelf?</td>
</tr>
<tr>
<td><strong>Total pain score: ______/50×100= %</strong></td>
<td>(7) Carrying a heavy object of 10 pounds</td>
</tr>
<tr>
<td><strong>Total disability score: ______/80×100= %</strong></td>
<td>(8) Removing something from your back pocket?</td>
</tr>
<tr>
<td><strong>Total SPADI score: ______/130×100= %</strong></td>
<td><strong>Total disability score: ______/80×100= %</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Practical application and psychometric properties</th>
<th><strong>Time to complete</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time to complete</strong></td>
<td>2–3 minutes to complete</td>
</tr>
<tr>
<td><strong>Translation</strong></td>
<td>Spanish, Chinese, Arabic, Danish, Norwegian, Dutch, Indian, Hindi, Greek, Turkish, Brazilian Portuguese, Persian, Thai, Nepali, Italian, German, and Korean</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Internal consistency (Cronbach’s alpha=0.86–0.96)</td>
</tr>
<tr>
<td><strong>Validity</strong></td>
<td>Test-retest reliability (intra-class correlation coefficient=0.84–0.95)</td>
</tr>
<tr>
<td><strong>Validity</strong></td>
<td>American Shoulder and Elbow Surgeon Score: r=0.77 in patients referred to an upper extremity clinic for shoulder problems</td>
</tr>
<tr>
<td><strong>Validity</strong></td>
<td>Short Form 36 physical component scale: r=−0.46 in patients with shoulder pain</td>
</tr>
<tr>
<td><strong>Ability to detect change</strong></td>
<td>Estimated minimal detectable change 18.1 for musculoskeletal upper extremity problems</td>
</tr>
<tr>
<td><strong>Ability to detect change</strong></td>
<td>Estimated minimal clinically important difference 13.2 for musculoskeletal upper extremity problems</td>
</tr>
</tbody>
</table>

SPADI, Shoulder Pain and Disability Index.
version. Considering its frequency of use and psychometric properties, the ASES can also be an excellent option; however, the issue of transcultural adaptation remains.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

6. Angst F, Schwyzter HK, Aeschlimann A, Simmen BR, Goldhahn J. Measures of adult shoulder function: Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and its short version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society Standardized Shoulder Assessment Form, Constant (Murley) Score (CS), Simple Shoulder Test (SST), Oxford Shoulder Score (OSS), Shoulder Disability Questionnaire (SDQ), and Western Ontario Shoulder Instability Index (WOSI). Arthritis Care Res (Hoboken) 2011;63 Suppl 11:S174-88.
Fact Sheet on Cardiac Rehabilitation for Cardiovascular Disease in South Korea

Ki-Hong Kim, MD, Jae-Young Han, MD, PhD

Department of Physical & Rehabilitation Medicine, Chonnam National University Medical School and Hospital, Gwangju, Korea

INTRODUCTION

Cardiovascular disease (CVD) poses a significant health challenge globally, including in Korea, due to its status as a leading cause of death and its impact on cardiopulmonary function. Cardiac rehabilitation (CR) is a well-established program that not only aids in restoring cardiopulmonary function, but also improves physical and social conditions. The benefits of CR are widely recognized, and it is implemented globally. While the effectiveness of CR has been proven in Korea, it is underutilized. This fact sheet summarizes the current status of CR in Korea, including the prevalence of CVD, the clinical practice guidelines for CR programs, and the challenges of implementing CR in Korea.

Keywords: Cardiac rehabilitation, Health services misuse, Practice guideline, Statistics

Cardiovascular disease (CVD) is the primary global cause of mortality, with ischemic heart disease accounting for approximately 12% of disability-adjusted life-years lost annually worldwide. Korea has a lower mortality rate than other countries, but trends of mortality and incidence vary depending on the type of CVD [1,2].

The number of patients with CVD is increasing, and CVD patients are now living longer with their symptoms due to major diagnostic and therapeutic advances in the past few decades. The extended survival of individuals with CVD is contributing to the growing prevalence of CVD, and the absolute number of CVD-related fatalities is expected to rise as the population ages [3-5].

Dual antiplatelet therapy is typically advised for a 12-month period following the onset of acute coronary syndrome. Secondary prevention measures are crucial to emphasize in order to reduce mortality rates. These include rigorous lipid-lowering therapy, antithrombotic treatment, and lifestyle modifications, which can be included in cardiac rehabilitation (CR) [1].

CR is a complex intervention that aims at enhancing cardiopulmonary function, well-being, and health-related quality of life in CVD patients. There is substantial evidence supporting the clinical and cost-effectiveness of CR for patients with acute coronary syndrome [6]. In Korea, numerous studies have confirmed the effectiveness of CR [7-10].

Although contemporary clinical guidelines strongly recommend referring CVD patients to CR, access to CR programs in Korea remains limited. About 40% of patients participate in CR worldwide, but in Korea, the participation rate is lower [11].

This fact sheet provides an overview of the epidemiology of CVD and the current status of CR programs in Korea, encompassing clinical practice guidelines and the implementation, effectiveness, and underutilization of CR. Since CVD is a very broad term, this fact sheet focuses primarily on coronary heart
diseases, such as acute myocardial infarction (AMI), angina, and heart failure.

**PATTERNS OF CARDIOVASCULAR DISEASE INCIDENCE, PREVALENCE, AND MORTALITY TRENDS IN KOREA**

**Incidence and prevalence**
Overall, the prevalence of CVD is increasing [2]. However, the trends in mortality and incidence vary depending on the specific type of CVD. Notably, heart failure is experiencing a rapid increase in both incidence and prevalence. The incidence of AMI peaked in 2006–2007 and has been gradually declining since then. However, it has recently started to rise again. Interestingly, while the incidence of myocardial infarction has not increased in specific age groups, its overall crude incidence seems to be rising due to the growing elderly population (Fig. 1) [12].

In 2016, the age-standardized incidence of hospitalization due to AMI in Korea was 43.2 cases per 100,000 people. When broken down by age group, the incidence of AMI per 100,000 people was as follows: The highest incidence was observed in individuals aged 80 or older, with 321.4 cases per 100,000 people. For those aged 70–79, the incidence rate was 197.4 cases per 100,000. The incidence for individuals aged 60–69 was 117.7 cases per 100,000, while those aged 50–59 had an incidence rate of 66.4 cases per 100,000. Among those aged 30–39, the incidence was 6.9 cases per 100,000. The lowest incidence was recorded for those under 29 years of age, at 0.3 cases per 100,000 [13].

**Mortality**
Until 1999, CVD was the leading cause of death. However, since that time, cancer has overtaken CVD, making it the second most common cause of death. Data on causes of death from 1983 to 2021, provided by the National Statistical Office of Korea, shows that the mortality rate from all circulatory system diseases decreased from 1982 to 2009, but then increased again from 2009 to 2021. Despite limitations in generalizability due to the inclusion of cerebrovascular disease, these statistics reveal the following trends. The mortality rate was 165.9 per 100,000 population in 1983, dropped to 109.2 per 100,000 population in 2009, and then rose to 121.5 per 100,000 population in 2021. The increase in mortality related to ischemic heart disease was primarily responsible for the overall rise in heart disease mortality in the early 2000s.

Conversely, the increase in heart failure mortality was asso-

![Fig. 1. Age-standardized incidence of hospitalization for acute myocardial infarction in Korea between 2007 and 2016. Adapted from the article of Kim et al. J Korean Med Sci 2019;34:e322 [12].](image-url)
associated with a rise in the 2010s. This recent surge in heart failure mortality in Korea can be primarily attributed to several factors, including an aging population, an increase in CVD survivors, and an improved rate of heart failure diagnoses (Fig. 2) [2,14].

In 2020, there were 9,927 deaths attributed to AMI. The crude mortality rate escalated with age, peaking at 19.3 per 100,000 population (21.8 for males and 16.8 for females). This rate dramatically increased to 260.7 per 100,000 population for individuals aged 80 or older. Importantly, the mortality rate was consistently higher in males across all age groups (Fig. 3) [13,15].

A study analyzing data from the National Health Insurance Service and the National Statistical Office revealed that in 2016, the hospitalization mortality rate (death within 7 days of hospitalization) for AMI patients in Korea who were hospitalized for more than one day was 2.8%. The mortality rates at 30 days, 90 days, 1 year, and 3 years were 6.2%, 8.8%, 13.1%, and 19.7%, respectively. It is notable that inpatient mortality decreased across all these time frames (30 days, 90 days, and 1 year) [13].

**Fig. 2.** Crude mortality of cardiovascular disease in Korea, 1983–2021. Adapted from Statistics Korea [14].

**Fig. 3.** Number of myocardial infarction patients (A) and prevalence of myocardial infarction (B) in Korea by year from 2016 to 2020. Adapted from the article of Kim et al. Epidemiol Health 2022;44:e2022057 [13].
CARDIAC REHABILITATION IN KOREA

CR is a multidisciplinary, team-based approach that involves both medical and non-medical professionals. This program is designed to deliver comprehensive, personalized care to patients with CVD. The level of evidence (LOE) is 1++. Typically, the program spans 6–12 weeks and is divided into three phases: inpatient, outpatient, and maintenance. The inpatient phase commences during hospitalization, with a focus on early patient mobilization and complication prevention. The outpatient phase encompasses exercise training, risk factor management, and psychosocial support. The maintenance phase is a lifelong commitment, aiming to sustain the benefits gained during the program and prevent future cardiovascular events. Exercise training is a crucial element of the CR program because exercise enhances cardiopulmonary function, provides symptom relief, and reduces mortality rates in patients with CVD. The exercise regimen usually includes aerobic and resistance training, tailored to individual needs and abilities (LOE: 2++). Risk factor management, including smoking cessation, blood pressure control, and lipid profile management, are also integral parts of the program (LOE: 1++) [6,16,17]. CR is utilized in various countries worldwide, with Western countries in particular having clinical practice guidelines for CR.

Each country organizes and applies these clinical practice guidelines for CR according to their specific circumstances [6,18].

Clinical practice guidelines for CR in Korea

In 2019, Korea established clinical practice guidelines for CR. The guidelines contain four main sections: Introduction, Assessments, Exercise Therapy, and Education for Secondary Prevention.

In the Introduction, the guidelines state that CR programs should be an integral component of the treatment approach for individuals recovering from acute coronary syndrome. The initiation of CR exercises should occur promptly following the acute phase of treatment. Additionally, these CR programs should adopt a holistic and interdisciplinary approach to address various aspects of patient recovery and well-being.

In the Assessments section, the guidelines state that customized CR plans should be meticulously crafted to align with each patient’s specific needs. These individualized plans should be based on comprehensive personal assessments of patients who have been referred to CR, including checking for psychological problems. Furthermore, cardiopulmonary exercise testing, which assesses patients’ cardiopulmonary exercise function, is essential for accurately prescribing exercises and predicting outcomes. If implementing a symptom-limited exercise test is challenging, it is advisable to consider using a submaximal exercise test, such as the 6-minute walk test, as an alternative approach.

In the Exercise Therapy section, the guidelines state that CR exercise programs should incorporate aerobic exercise as a fundamental component (or, for better results, high-intensity interval training), as well as resistance (strengthening) exercises. For patient safety during CR exercises, appropriate monitoring should be carried out based on the risk assessment results. Home-based CR programs can be a viable alternative to hospital-based CR programs, especially for low-risk patients. Additionally, it is essential to expand CR programs to include patients aged 65 years or older, as they can benefit significantly from these interventions to improve their cardiovascular health and overall well-being.

In the Education for Secondary Prevention section, the guidelines indicate that a smoking cessation program should be provided. Continuous programs of at least 4 weeks should be considered, and diet programs should also be designed. Food supplements are generally not recommended as a primary or sole strategy for secondary prevention of CVD [7].

Regional cardiocerebrovascular centers in Korea

CR is being implemented through collaboration with the 14 regional cardiocerebrovascular centers (RCCs) in Korea. The locations are as follows: one each in Gyeonggi, Incheon, Gangwon, Daejeon-Chungnam, Chungbuk, Jeonbuk, Busan, Gyeongnam, Ulsan, and Jeju and two each in Gwangju-Jeonnam and Daegu-Gyeongbuk.

RCCs were established to reduce the mortality and morbidity caused by cardiocerebrovascular disease (CCVD) through systematic and efficient operations throughout the entire CCVD cycle, including prevention, early diagnosis, emergency treatment, education, rehabilitation, and management. RCCs actively engage in efforts to narrow healthcare gaps across regions, and their CR programs are expected to serve as examples for post-acute CVD management in Korea.

There are 164 hospitals in Korea that perform percutaneous coronary artery intervention, which include the RCCs (103 are hospitals certified by the Korean Society of Interventional Cardiology). Of these 164 hospitals, 47 (29%) have CR programs (Table 1).
Research on Korean RCCs has indicated that 12 have the equipment, facilities, and medical personnel necessary for CR assessments (two RCCs were excluded from the study due to their short operational period). In addition, patient referral and education are performed relatively well at RCCs, as indicated by the CR referral rate (97%) and the patient education rate (78%). However, the inpatient CR exercise-training participation rate is about 56% and the enrollment rate is 47%, which are lower than the referral rate and the patient education rate. Notably, the outpatient CR program compliance rate is even lower, at around 17% [19,20]. The participation rate refers to the percentage of patients who have undertaken an exercise program for CR. The enrollment rate denotes an outpatient visit for CR following discharge. Finally, adherence refers to the completion of a CR program, which typically lasts between 6 to 12 weeks.

Effectiveness of CR in Korea

As previously noted, CR has numerous beneficial effects. It not only reduces mortality and re-hospitalization rates, but also prevents the recurrence of cardiovascular events and enhances health-related quality of life [6]. The efficacy of CR has been proven by various studies conducted in Korea.

The Eleven Tertiary Hospitals In Korea (ETHIK) study revealed that the 5-year survival rates for participants in CR and non-participants were 96.9% and 93.3%, respectively. The risk ratio for the total 5-year mortality rate among CR participants was approximately 0.41 times that of non-participants. Furthermore, the 5-year survival rate for patients who had suffered an AMI and participated in CR was 59% higher than for those who did not participate [10].

Other reviews have found that the group participating in CR experienced a 28% lower overall mortality rate compared to the group receiving conventional treatment. Additionally, the CR group had lower rates of recurrence and major adverse cardiovascular events compared to the non-CR group. The number of re-hospitalizations was also fewer in the CR group [8]. In Korea, the recovery of cardiopulmonary functions and the improvement of health-related quality of life due to CR have been substantiated. Cardiopulmonary function significantly increased during the initial 12 weeks of CR, and this improvement was sustained for nearly a year [9,18].

### Table 1. Regional distribution of RCCs and hospitals performing PCI and CR in Korea

<table>
<thead>
<tr>
<th>Region</th>
<th>RCC</th>
<th>PCI hospital</th>
<th>CR hospital</th>
<th>Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>0</td>
<td>31</td>
<td>13</td>
<td>42</td>
</tr>
<tr>
<td>Gyeonggi</td>
<td>1</td>
<td>33</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Incheon</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>Gangwon</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
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<td>Jeju</td>
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<td>47</td>
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</tr>
</tbody>
</table>

Adapted from the article of Kim et al. J Clin Med 2021;10:5079 [19].

RCC, regional cardioireovascular center; PCI, percutaneous coronary intervention; CR, cardiac rehabilitation.

*a*Province or metropolitan area.

*b*Hospitals that perform PCI.

*c*Hospitals with CR programs in the region.

*d*An RCC was established in the Jeonnam region in 2020 but was not included in the 2021 study.

*e*An RCC was established in the Gyeongbuk region in 2020 but was not included in the 2021 study.

### UNDERUTILIZATION OF AND BARRIERS TO CARDIAC REHABILITATION

Despite the benefits of CR, its implementation faces several challenges in Korea. CR is strongly recommended, but the actual global CR participation rate is only about 30%-40% [17], and countries are striving to boost participation rates. In contrast, the participation rate in Korea is merely 1.5%, which is significantly lower than in many other countries [21].

There are various reasons for the low participation in CR in Korea. Numerous studies have been conducted to identify the causes, which primarily relate to patient-related factors, hospital-related factors, and factors related to governmental health policies in CR.

Patient factors that reduce participation in CR often include logistical issues or comorbidities/functional statuses. Groups that particularly exhibit low participation rates include the elderly, females, and rural residents. The reduced participation rate among elderly patients can be attributed to mobility challenges related to comorbidities, as well as transportation limitations. The lesser involvement of women in CR programs may be due to their greater family responsibilities and a lack of free time. Furthermore, the self-reliant attitudes common in rural areas, combined with limited access to medical facilities,
may lead to lower CR participation among rural residents. The inability of patients to accurately recognize the need for and the importance of CR, along with issues of accessibility, cost, and time constraints, also contribute to the low CR participation rate [21-24]. Factors within hospitals that contribute to reduced participation in CR include limited access to CR services, with only a small fraction of patients participating in CR. This is often due to a lack of physician referrals, as many physicians either lack awareness of the benefits of CR or do not prioritize it within their treatment plans [22,23]. A 2020 study revealed that out of 164 hospitals in Korea performing percutaneous coronary interventions, only 47 hospitals (29%) had implemented CR programs, despite being certified by the Korean Society of Interventional Cardiology [20].

There is a lack of public awareness and education about the benefits of CR because many patients and their families are not aware of the program or do not understand its purpose. Therefore, it is important to raise public awareness and provide education about the benefits of CR, as well as its potential to improve patient outcomes. Home-based CR enables patients to continue receiving CR after their cardiopulmonary function has been evaluated in hospitals. However, this approach also leads to underutilization [22,24,25].

Governmental health policy factors also contribute to low CR participation. In Korea, the National Health Insurance Service began providing insurance coverage for CR in February 2017. A survey study aimed at promoting CR participation revealed that healthcare providers underscore the importance of government-provided patient incentives. They perceive the government as playing a pivotal role in ensuring both the time and the right for patients to participate in CR [24]. There is also a shortage of hospitals that offer CR, indicating a need for government attention and effort to introduce community-based programs that can be managed on an ongoing basis [25].

We propose several strategies to address these barriers. To counter low participation rates due to a lack of understanding

| Table 2. Barriers and ways to overcome the underutilization of cardiac rehabilitation |
|---------------------------------------------|-------------------------------|
| **Barriers**                               | **Ways to overcomes**         |
| Patient factors                            |                               |
| Referral                                   | Lack of awareness of CR       |
| Enrolment                                  | Cost burden                   |
| Adherence                                  | Psychosocial problems         |
| Accessibility issues                       | Lack of time                  |
| Restriction of participation in elderly and female patients |                   |
| Hospital factors                           | Lack of referrals              |
| Referral                                   | Lack of awareness of CR       |
| Enrolment                                  | Lack of various CR programs   |
| Governmental health policy factors         | Socio-cultural factors        |
| Referral                                   | Cost burden                   |
| Adherence                                  | Accessibility issues          |
|                                       |                               |
|                                       |                               |

CR, cardiac rehabilitation.
about the importance or effectiveness of CR, we recommend promoting education about CR to both patients and healthcare providers. Active recommendations from medical staff, comprehensive education on the need for CR, motivational interviewing, and increased autonomy for participation (e.g., scheduling appointments, setting time schedules, and choosing locations) can all contribute to increased participation in CR. Improvements to the insurance system are also necessary to facilitate the active introduction of CR. Hospitals could offer a range of incentives or implement patient-customized CR programs. Another potential solution is the introduction of an automatic referral system or the strengthening of connections with community-based or home-based CR programs. These programs could be offered to patients who are unable to participate due to travel constraints, and the provision of transportation could be considered. To alleviate the cost burden, expanding insurance coverage could be beneficial. Additionally, various campaigns, studies, and research projects will be necessary to raise awareness about CR and underscore its importance at the government level (Table 2) [21-25].

**CONCLUSION**

While the mortality rate from CVD has declined in Korea, the overall burden of CVD continues to rise. This increase is primarily attributed to the rapidly aging population and the growing number of individuals diagnosed with CVD, a trend that is expected to continue. CR is being implemented in Korea for CVD patients, offering numerous benefits such as improved cardiopulmonary functions and reduced risks of re-hospitalization and mortality. Additionally, RCCs are striving to bridge the regional disparities in CR access (Table 3). However, compared to other countries, the participation rate in Korea remains relatively low. The implementation of CR continues to face numerous obstacles, including a lack of awareness, system participation, and medical costs. In this review, we provide an overview of CR in Korea, a resource that healthcare professionals and policymakers can use to strategize for CR implementation.

**CONFLICTS OF INTEREST**

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**AUTHOR CONTRIBUTION**

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**REFERENCES**


3. Townsend N, Kazakiewicz D, Lucy Wright F, Timmis A, Huculeci R,
INTRODUCTION

Post-stroke spasticity (PSS) and post-stroke spastic movement disorder (PS-SMD) are common conditions following stroke that include damage of the sensori-motor networks in the central nervous system (CNS) [1]. PSS is characterized by involuntary activation of skeletal muscles resulting in phasic and/or tonic muscle activity during rest and voluntary movement resulting in the PS-SMD in involved body-parts [2]. PSS is the result of the so-called positive signs of the upper motor neuron syndrome (UMNS). These positive signs of the UMNS are (a) spontaneous or triggered (stretch- or touch-induced) clonus activity or spasms during rest or movement; (b) spontaneous antagonistic co-activation during rest called spastic dystonia; (c)
involuntary spastic co-contraction of the antagonist while voluntary activation of the agonist; (d) velocity-dependent increase in muscle tone during rest; (e) increased tendon reflexes; and (f) Babinski sign and other pathological reflexes during rest or triggered by touch or movement [2,3].

Most of the prevalent data of PSS originates from studies that only used the criterion of velocity-dependent increase in muscle tone as a clinical marker of PSS [1,2]. This prevalence is high in the first year after first ever stroke, affecting up to 43% of stroke survivors [1,4]. PSS, resulting PS-SMD and complications can be a major contributor to stroke-related disability, low quality of life, and reduced social and professional participation [2]. PSS or PS-SMD that is perceived by the affected individual or care giver as hindering body functions, activities, and/or participation is defined as disabling PSS or disabling PS-SMD [2,4]. Published prevalent data of a severe spasticity (defined as increased muscle tone equal or more than 2 of the modified Ashworth scale [MAS]) and a disabling PSS (defined as spasticity that does need treatment) showed that up to 13%–16% of stroke survivors suffer from this complication after stroke [2,4,5].

The symptom velocity-dependent increase in muscle tone, characterized by resistance to passive stretch of the affected skeletal muscles, is still the key qualitative symptom that leads to the diagnosis and allows to characterize the topical distribution of the PSS over the body regions [2]. The documentation of the muscle tone with the Ashworth scale (AS), MAS, or Tardieu scale (TS) as a clinical quantification of the PSS is well established in most of the interventional and pivotal studies [2]. For a state-of-the-art-documentation and a precise communication of the topical distribution of the PSS the classification of the distribution as focal, multi-focal, segmental, multi-segmental, or generalized PSS is recommended [3,6,7]. For a standardized calculation of the severity of e.g., hemispasticity, para-, or tetraparespasticity for calculation of sum scores the RESistance to PAssive Stretch scale (REPAS) with defined test positions and set of well standardized passive stretchings using the AS is recommended [8].

PS-SMD is associated with negative features of the UMNS namely muscle weakness, fatigue and fatigability creating dexterity problems with slowing and less forceful or even no voluntary movements in the affected body region. Therefore, the term spastic paresis (SP) is also used to describe the clinical picture on an impairment level in PS-SMD since it combines PSS (involuntary muscle activity) with muscle weakness, which are commonly present in the UMNS [2,9].

The UMNS with a PS-SMD consists of neuronal changes and progressive muscle and soft tissue changes. These changes shorten the involved structures and lead to a progressively reduced range of motion (ROM). This aspect of the UMNS is called the non-neuronal component, which led to the establishment of the term deforming spastic paresis (DSP). In the 2005 definition of Pandyan et al. [9], this non-neuronal component and the negative sign paresis of the UMNS are not part of the SPASM definition of spasticity.

Another severe complication resulting from a PS-SMD is the syndrome of spasticity-associated pain, which could be diagnosed by eliciting stretch-induced noxious pain in spastic muscles in affected body regions [2,10]. The pathophysiology is not totally understood, but the hypothesis is that it correlates with the quantity of some positive features of the UMNS (especially spastic dystonia) and also with malpositioning, sensory loss, and neglect syndrome that affect the involved limbs. Large randomized controlled trials (RCTs), cohort studies, and pooled data analysis of stroke survivors in the chronic phase showed that up to 64% of patients with PS-SMD had pain in the paretic limbs to some degree [10]. Both, randomized controlled studies and pooled RCTs [10] demonstrated a significant reduction of spasticity-associated pain if muscles are treated with botulinum toxin A (BoNT-A). This applies for all a focal, multi-focal, and segmental BoNT treatment regimens.

Currently, there is still no causal treatment for PSS and the resulting PS-SMD. However, various symptomatic therapeutic approaches have been introduced and discussed for managing PS-SMD [2]. In this article we provide information concerning the pathophysiology of PSS and its prediction, as well as the clinical assessment, management strategy including goal setting and multimodal treatment options with a focus on evidence-based methods and BoNT-A treatment.

**PATHOPHYSIOLOGY OF PS-SMD**

For the first time, an international group of specialists in neurology, neurorehabilitation, and restorative neurology defined the different relevant pathophysiological phases following first-ever stroke [11]. According to the panel, there are four main phases after acute ischemic or hemorrhagic lesion of the cortical and subcortical brain tissue. These phases show specific histopathological and/or pathophysiological correlates: The *Hyperacute Phase* (within the first hours to 24 hours), the *Acute Phase* (first day to a week), the *Subacute Phase* (after first
In the hyperacute and acute phase necrosis of the brain tissue happens with local inflammatory and secondary neuro-degenerative processes at and around the lesion site. In the first hours after stroke cortical and subcortical sensori-motor networks structures show acute loss of function in involved movement segments on the contralateral body side with acute flaccid palsy and/or sensory loss. In this phase the limb is dependent on passive positioning, as there is a high chance of no voluntary control of the position of the limb. The loss of sensation results therefore in a high risk of secondary damage due to malpositioning [11-13].

With a latency of days to weeks neuroplasticity starts with re-connection of residual neurons and rewiring of new connections of the lesioned area to new neuron pools in the sensori-motor network nearby. These complex and often overlapping processes happen with variable latency (days to weeks) in the late acute and early post-acute phases [11,12]. From epidemiological studies of large cohorts of stroke survivors, it is known that about 20% develop a SP [1]. The emerging regain of movements to a certain extent is paralleled by involuntary muscle activity, that is defined as spasticity [9,14]. In other words, the start of regaining of some voluntary muscle force and sensation could be concurrent altered by involuntary muscle activity, which is defined as spasticity or positive signs in the context of an UMNS [9,13,14].

The involved neuronal mechanisms resulting in an increased excitability of the sensori-motor spinal networks and promoting involuntary muscle activity are due to an imbalanced descending regulation of the spinal sensori-motor network. There is an imbalance between descending inhibitory dorsal reticulospinal tract (RST) and the excitatory medial RST and vestibulospinal tract and/or abnormal intraspinal processing of sensory input (enhanced sensitivity of Ia and II afferents, and reduced presynaptic inhibition on Ia-afferents, as well as facilitation of group lb and II afferents) [13,15-17].

Additionally, there is also evidence of a shift of the chloride equilibrium potential in spinal cord motoneurons due to an altered function of the chloride extrusion mechanisms (KCC2) resulting in excitatory effects of GABA and glycine on motoneurons [18].

In this stage the affected limb develops to some extent the so-called spastic movement pattern that shows typical dysbalanced movements, joint positions with slowing in its performance compared to physiological movements on the less affected body side. By definition, if involuntary muscle activation is included in those typical movement patterns in a central paresis, this syndrome represents a PS-SMD [12].

Whether regaining of any sensori-motor function ends with either a residual loss of function or a regaining of most of the functions in the upper and lower limb in the late post-acute or in the chronic phase seems to be dependent of various factors. For sure, the lesion size in the sensori-motor cortical and subcortical network is important for both regaining any function [19] and for the development of spasticity/PSS [20,21]. The following clinical signs represent negative predictors for a good outcome and an high risk for the development of a severe PS-SMD: severe sensory loss, neglect or other relevant neuropsychological changes, paralysis or severe paresis without development of functional relevant muscle force (MRC below 3), severe PSS in multiple joints and adaptation to a severe PSS (MASE > 2), development of a DSP with contractures and spasticity-associated pain [2]. The progressive so-called non-neuronal changes of muscles and soft tissue in the late post-acute and chronic phase (DSP) may lead to further functional impairments with progressive joint contractures, spasticity-associated pain and skin irritation or even skin lesions [22,23].

In summary, the Acute and Early Subacute Phase (first weeks to 3 months) is characterised by the start of reorganisation of the sensori-motor network. In this phase SP develops and involuntary muscle activity add the risk from paresis and may result in the development of complications from PS-SMD with development of contractures, spasticity-associated pain and DSP [1]. In the Late Subacute Phase (3–6 months) in most cases the development of PS-SMD is established and the sensori-motor system shows signs of (mal-) adaptation to involuntary muscle activity in up to 42% of stroke survivors [1]. In 13% this led to a syndrome of disabling PS-SMD [2,4]. Later on, in the Chronic Phase an established PS-SMD may further worsen with progressive immobility, joint contractures, stretch-sensitive spasticity-associated pain, and abnormal movement patterns [4,12].

The knowledge of the pathophysiology of the PS-SMD and its different time phases following a first-ever stroke is crucial for appropriate management strategies of an underlying UMNS with high risk of the development of a DSP [3,11,12,22]. However, the interconnection between the various facets of the neuronal and non-neuronal mechanisms of PS-SMD with involuntary muscle activity, defined as spasticity by the SPASM-group [9], on the one hand, and progressive muscle degeneration
(loss of myofibrills) and muscle and soft tissue shortening and stiffening are not yet fully understood [22-24]. The time scales of mechanisms of degeneration and reorganization parallels to some extent the time scale of neuroplasticity of the sensori-motor nervous system and peripheral tissues in the subacute phase [17,23].

Several cohort studies could show that changes in muscles and peripheral soft tissue (changes in tissue matrix, storing of collagen, degeneration of muscle fibres) starts already within a few weeks after first ever stroke [11,12]. Unfortunately, it is not fully understood yet, whether there are specific risk or trigger factors causing those tissue changes or whether it is the natural course after a first ever stroke.

Because there is currently no causal treatment for PS-SMD and it seems to develop in the Acute and Early Subacute Phase following stroke, it is crucial to catch the symptoms early and identify potential predictors of a PS-SMD to promptly initiate an appropriate management consisting of both physical and medical treatment [2]. Given the high prevalence of stroke as well as of a disabling PS-SMD, it has been strongly recommended for any initiating efforts to detect and treat early symptoms of PS-SMD as early as possible [2,12]. This is to achieve effective symptomatic management and avoid complications and maladaptation to PSS.

Early PSS detection and management may imply a better chance for a better outcome of patients, who passed a comprehensive person-centered neurological rehabilitation program following stroke. Timely and appropriate physical management and medical treatment, including BoNT-A treatment, seems to be crucial to prevent further disability from PSS to DSP in the context of a PS-SMD and may improve the outcome for individuals suffering from PS-SMD [2].

**MANAGEMENT OF PS-SMD**

**The prediction of PS-SMD and goal setting**

The PS-SMD typically emerges between days and three months after the first-ever stroke. The prevalence of a PS-SMD increases with time and reaches a plateau at about three months after the stroke (Fig. 1) [1,2].

Chronic PS-SMD is considered as a phenomenon of post-stroke maladaptation, associated with neuronal re-organization within the CNS during a critical period of three to six months after stroke [17]. This three to six-month period is characterized by complex processes involving immunologic responses that aim to limit the damage caused by stroke but can also lead to further damage to the affected tissue [2,17]. The window of neuroplastic re-organization might increasingly narrow over six months indicating the importance of early detection and intervention to avoid hardly reversible maladaptation to PS-SMD [1,2].

![Fig. 1. Prevalence of post-stroke spasticity.](image-url)
Prediction of PS-SMD

Many studies have identified clinical and brain-imaging data as predictors for early detection of patients at high risk of developing disabling PS-SMD (Table 1) [25-35].

Based on published predictors of PS-SMD a group of experts in the field published “The PSS Risk Classification System” to allow for prediction and identifying patients at risk to develop a PS-SMD within the acute and post-acute phases following a stroke [35,36]. This tool focuses on early identification of clinical and imaging risk factors and provides recommendations for managing PS-SMD.

Recent publications have identified additional red flags for predicting a PS-SMD. This includes high scores on the modified Ranking scale (mRS), the National Institute of Health Stroke Scale (NIHSS), and lower than 27 scores for mini-mental status examination (MMSE) within the first week after first ever stroke [37].

In addition to these clinical predictors, specific brain lesion localizations and volume were found to predict a PS-SMD, too. Lesions involving the basal ganglia, thalamus, insula, and white matter tracts (such as the internal capsule, corona radiata, external capsule, and superior longitudinal fasciculus) on cerebral magnetic resonance imaging scans taken in the first week after stroke have a high predictive value for PS-SMD when the lesion load affects the cortico-spinal tract. Larger lesion sizes in these areas also increase the risk for developing a PS-SMD [2,20,21].

Goal setting and attainment

Before starting with a rehabilitation program, a systematic examination of the patient with spastic movement disorder is necessary to identify the relevant problems on the levels of impairment, activities, and participation of the individual patient. This examination should include a detailed case history of the stroke with a detailed description of the evolution of the spastic movement disorder. If relevant, also other medical issues should be evaluated. This should be followed by a comprehensive neurological examination by the physician as well as a clinical evaluation by the members of the multiprofessional therapeutic team, specialized in the management of spastic movement disorder [2].

On the basis of this thorough evaluation realistic short- and long-term goals for the comprehensive person-centered rehabilitation program have to be established, always in collaboration with the patient/caregiver and members of the multiprofessional team (MPT). An expert physician in neurorehabilitation, specialized in the management of spastic movement disorder, should guide this important discussion on goals for the rehabilitation program. Patient-centered goal setting, aligned with the International Classification of Functioning, Disability and Health, can help to manage activity limitations or functional impairments [2,38].

Collaboration among patients, caregivers, clinicians, and the MPT is essential to define desired treatment outcomes for BoNT-A injections in a multimodal treatment program. The SMARTER matrix, which stands for Specific, Measurable, Agreed, Realistic, Time-bound, Evaluated, and Revised goals, can help in developing realistic individual goals. After agreement of realistic goals, the team formulates a PS-SMD-reha-

Table 1. Known predictors of post-stroke spastic movement disorder

<table>
<thead>
<tr>
<th>Baseline (acute phase first week following stroke)</th>
<th>Any other time point (post-acute phase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe paresis (led to spasticity by 6 months) [25-28]</td>
<td>Paresis (led to spasticity by 6 months) [25,26]</td>
</tr>
<tr>
<td>Low FMA (led to spasticity by 12 months) [29]</td>
<td>Increased muscle tone (led to severe spasticity by 12 months) [29,30]</td>
</tr>
<tr>
<td>Increased muscle tone (mAS≥1 led to spasticity by 3–6 months) [25]</td>
<td>Hemiparesis &amp; low BI score (led to spasticity by 12 months) [31]</td>
</tr>
<tr>
<td>Moderately increased muscle tone (mAS≥2 led to severe spasticitya by 3–6 months) [26]</td>
<td>Low BI score, left-sided paresis (led to severe spasticitya by 12 months) [31]</td>
</tr>
<tr>
<td>Low BI score &amp; EQ-5D (led to severe spasticitya) by 3–6 months) [25,26]</td>
<td>Severe NIHSS, low Motricity Index (led to spasticity by 3 months) [32,33]</td>
</tr>
<tr>
<td>Hemihypesthesia (led to spasticity by 6 months) [26]</td>
<td>Extensive stroke lesions on CT &amp; MRI (led to spasticity between 5 days and one year) [20,34]</td>
</tr>
<tr>
<td>High mRS+high NIHSS+low MMST (led to spasticity by 6 months) [29]</td>
<td>Severe paresis (led to spasticity by 12 months) [30]</td>
</tr>
</tbody>
</table>

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All risk factors were shown to be significantly (p<0.05) predictive of post-stroke spasticity in at least one study [35].

FMA, Fugl-Meyer Assessment; mAS, modified Ashworth Scale; BI, Barthel Index; EQ-5D, standardised instrument of health-related quality of life; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; MMST, mini-mental status test; CT, computed tomography; MRI, magnetic resonance imaging.

aSevere spasticity: mAS≥3 [35].
bilitation plan adapted on the patient's individual needs and abilities. If the impairment positive symptoms of a UMNS result in a SMD with a focal, multi-focal or segmental distribution, the multiprofessional rehabilitation program should include a management with BoNT-A [2,39].

Goals selected together with the patient and/or caregiver can be categorized into two domains: (1) symptoms and impairment, such as pain, involuntary movements, and ROM/contracture prevention, and (2) activities and functions, including passive and active function, as well as mobility [2].

During the individualized rehabilitation program assessing goal attainment is a main component of clinical assessment and optimal management of PS-SMD. Goal attainment scaling (GAS) is a commonly used tool for evaluating treatment goals, where patient-specific SMARTER goals are tracked using a standardized scale. It encourages patient’s engagement in goal setting and has a positive impact on goal achievement, with evidence showing that involving patients in goal setting increases their likelihood of success [2,39].

The management of PS-SMD with BoNT-A

The efficacy of BoNT-A in the treatment of PS-SMD has been extensively studied. BoNT-A is considered as the treatment of choice for focal, multi-focal, and segmental PS-SMD, including spastic hypertonia, increased muscle tone, spastic dystonia, clonus, and spasms [2,3,5,6].

Numerous double-blind studies and systematic reviews have demonstrated improvements in reducing muscle tone and passive function in spastic limbs after stroke [2,3,12]. BoNT-A has been shown to reduce spasticity-associated pain, improve hygiene by increasing the passive range of joint movements, and reduce malpositioning of limbs caused by spastic dystonia and shortening of muscles due to spastic movement patterns [2,12,39]. It has also been proven to enhance active functional gains in certain subgroups of patients with PS-SMD who have difficulties with active movements due to simultaneously activated antagonists or increased muscle tone of antagonist muscles, such as reaching, gripping, or relieving movements with the hand or antagonistic ankle movements [40].

The onset of the effect of BoNT-A in SMD typically occurs between 2 and 5 days after intramuscular injection, with maximal effect observed at 3–4 weeks. This clinically significant effect of BoNT-A lasts for 6–10 weeks, after which it gradually declines. The duration of the effect mainly depends on the injected dose of BoNT-A per muscle. As the uptake in the motor endplate of BoNT-A is an active process, induced contractions by passive stretch an/or electrical stimulation of the injected muscle after BoNT-A injection may help to increase and extend its effect size and duration. The overall effect of BoNT-A treatment typically lasts for about 3–6 months following injection [2,41].

Controlled studies have shown that early BoNT-A intervention within 3 months following stroke, can result in a longer duration of improvement of both spastic muscle tone and passive function while reducing the occurrence of complications like tendon shortening in long finger flexor tendons with a lower dose of BoNT-A per injected muscle [2,12,42]. However, up to now the evidence does not indicate higher functional gains or effects on disability with earlier interventions with BoNT-A following stroke.

BoNT-A treatment in SMD has a good safety profile when used within the recommended therapeutic dose per muscle and treatment session and with proper injection techniques [2]. Common local adverse events include unwanted weakness of injected muscles, dysphagia (injection in cervical muscles), dry mouth and eyes, local pain, bleeding, or hematoma at the injection site. These side effects are reversible and not life-threatening. Systemic adverse events are rare and seemed to be less frequent if recommended doses are injected by use of guidance techniques directly into the target muscles in PS-SMD [2,41].

In the upper limbs, BoNT-A management of spastic movement disorder has shown dose-dependent effects in reducing spastic muscle tone, improving passive ROM and passive function, and reducing caregiver’s burden. However, the effects on active functions of the hand or arm are limited [2,39]. BoNT-A injections may improve active function in some patients with spasticity of the upper limb, especially when spastic co-contraction of antagonistic muscles is the relevant cause of hindering active finger or elbow from movement. In such cases the injection of BoNT-A in spastic agonists is recommended to combine with active training of motor command and force for antagonistic muscle groups thereby allowing for improvements also in active function, e.g., finger, wrist, or elbow extension [2,10,39].

In the lower limbs, BoNT-A injections can be considered for clinically relevant lower limb PS-SMD that does not respond to conventional physiotherapeutic treatment. BoNT-A injections were shown to reduce spastic muscle tone and to improve passive joint mobility and joint position in the ankle, knee, and hip. Pivotal studies in the lower limb of BoNT-A products showed significantly reduced pes equinus and pes equinovarus position with reduced muscle tone in the calf muscles and improved
brace or orthosis tolerance. However, significant improvements in longitudinal gait parameters (gait speed and step length) have not been consistently observed [2,40,43].

BoNT-A treatment also showed reduced spasm frequency and clonus occurrence, as well as reduced stretch- or motion-related spasticity-associated nociceptive pain in both upper and lower limbs after stroke [2,3,6].

The technical guidance of BoNT-A injections, such as ultrasound or electrical stimulation guidance, improves the accuracy, safety, and efficacy of the injections compared to non-guided injections. Guided injections have been shown to be superior in terms of injection accuracy and avoidance of accidental vessel and nerve injury [2,41].

The appropriate dosing of BoNT-A is crucial for treatment effectiveness and to minimize adverse events. Dosing recommendations are currently based on limited studies and rely on pivotal studies that are documented in the product information, clinical experience of injectors, and expert consensus statements [2,3,41].

Recommended doses per injection site base on the assumption of a saturation of the motor endplates and led to the recommendation not to inject more than 50 units for onabotulinumtoxinA and incobotulinumtoxinA, and 125 units for abobotulinumtoxin A per injection site. Therefore, the number of injection sites per muscle depends on the maximal recommended dose per specific muscle. As a rule of thumb the recommended doses vary for different muscle sizes, ranging from 15–25 units onabotulinumtoxinA and incobotulinumtoxinA, and 35–75 units for abobotulinumtoxin A for small limb muscles to 50–150 units onabotulinumtoxinA and incobotulinumtoxinA, and 125–500 units for abobotulinumtoxin A for large limb muscles [2,41].

As spastic muscle patterns of upper and lower limbs usually involve more than two or three muscles it seems to be important to calculate the total dose per injection session prior to the event and respect the maximum dose per injection session given in the product information and from expert consensus statements [2,41]. There are prospective studies that could show a superiority with respect to the benefit with higher dose, but for certain BoNT-A products, only [44]. More research is needed in this field to learn more about the safety margins of the different BoNT-A products.

Adjuvant therapies to botulinumtoxin injections
Evidence-based reviews report an enhanced effectiveness of adjuvant therapies to BoNT-A injections in spastic muscles in PS-SMD [2]. Such techniques include physiotherapy, modified constraint-induced movement therapy, electrical stimulation, casting, and dynamic splint treatment. Neuromuscular electrostimulation applied three days before and after BoNT-A therapy has shown positive effects on effect size and duration of BoNT-A injections. Other adjuvant therapies like stretching, taping, and robotic training may be used on an individual basis, but the published evidence on additional effects is limited [2].

Oral antispastic drugs have shown significant systemic side effects like sleepiness, drowsiness and general weakness and do not have sufficient evidence to support their superiority over local BoNT-A treatment in focal, multi-focal and segmental spasticity. But some studies have demonstrated effectiveness of systemic drugs like tizanidine or baclofen [2]. On the basis of clinical experience, in some patients the drug side effect ‘sleepiness’ may help for positive effect on lower limb spasms during night. Such timed drug therapy may be combinable with BoNT-A injections for treatment of a pes equinus or ankle clonus within the calf muscles.

A combination of diverse treatment modalities involving neurolysis (phenol, alcohol, or cryo-neurolysis) or even neurotomy with BoNT-A injections can be considered for PS-SMD that shows a multi-segmental or generalized topical distribution and does not respond adequately to recommended dose per session [2,45]. If the BoNT-A dose per session exceeds the limit documented in the product information or in consensus statements a combination of neurolysis of motor end branches or dominat motor nerves, like musculo-cutaneous or obturator nerve, are recommended in order to reduce the total dose of BoNT-A per session. However, the side effects and the long-term side effects of neurolysis should be taken into account [2,45].

Intrathecal baclofen (ITB) application can be considered for severe multi-segmental or generalized PS-SMD that does not respond to other interventions, e.g., systemic oral pharmacological antispastic treatment [2,3]. For ITB therapy was shown a superiority over conventional medical management with oral antispastics in terms of efficacy and pain control [46]. Surgical procedures, such as fasciotomy, tendon and muscle lengthening, and tendon transfer surgery, may be considered in chronic PS-SMD cases after exhausting of other reversible treatment options [2]. More research is needed to provide evidence for orthopedic surgery in the management of chronic PS-SMD and its combination with BoNT-A treatment.
BoNT-A therapy in the Acute and Early Subacute Phase following stroke

PS-SMD typically develops in the early post-acute phase of stroke, within the first three months [2,12]. Unfortunately, clinical detection and decision-making for appropriate management in many countries usually occur later, e.g., in the late sub-acute or even in the chronic phase [1,2]. In the late sub-acute phase degenerative changes in affected muscles and soft tissues already start and lead to more frequent complications like joint contractures, spasticity-associated pain syndromes, abnormal motion and limb patterns and even bony distortions can occur in the chronic phase - if the SMD is not adequately managed in the early sub-acute phase [2,13,17].

Studies have shown that early initiation of treatment after stroke could have beneficial effects on the reduction of spastic muscle tone without increased side effects [2,12,47]. Meta-analysis and systematic reviews indicate more favorable outcomes and better prognosis with early treatment compared to late treatment in the chronic phase of PS-SMD [2,12,42].

Based on the pathophysiological mechanisms leading to a SMD it has been considered to maintain or provide a normal sensory and proprioceptive input to the disrupted central sensorimotor network to prevent from adaptation or even mal-adaptation re-organization. BoNT-A injections in SMD developing muscles support to prevent the central network from overactive peripheral sensory input from intrinsic muscle fiber and tendon receptors (IA- and IIb-fibers). The pathologically enhanced tonic and phasic input on the spinal sensorimotor network via the proprioceptive system is believed to be one of the key factors for maintenance and augmentation of the spastic movement disorder [12,13,16,48]. It is hypothesized that this input to the spinal network from spastic muscles may play a significant role in the maladaptive processes in the CNS that leads to the chronic consequences from PS-SMD in UMNS [13,15-17,48].

It is suggested that the three-month transition phase following stroke is a period of enhanced neuroplasticity allows effective interventions. Such interventions include blocking afferences from spastic muscles thereby avoiding the development of complications like contractures and spasticity-associated pain syndromes. This is achievable by BoNT-A treatment in spastic muscles before the transition in the late post-acute phase. Therefore, this transition marks the cut-off for early vs. late BoNT treatment [12].

Based on the evidence that appropriate predictors are sufficient to detect patients at risk for developing a PS-SMD after a first ever stroke, it seems now possible to treat PS-SMD with BoNT-A already in the acute or late early subacute phase, i.e., within the first 3 months after stroke [2,12,42]. Treatment of PS-SMD with BoNT-A injections should be offered to those high risk patients to avoid complications from severe spasticity, e.g., contracture development. As well, involuntary muscle activity should be blocked early to avoid maladaptation to a disturbed feedback on the spinal network by increased IA- and II-afferences from hyperactive muscle activity, e.g., from spastic dystonia. Spinal cord sensori-motor networks can be protected from an enhanced muscle/tendon proprioceptive input by early BoNT treatment. By doing this, the vicious circle can be interrupted and neurorehabilitation is facilitated. Insofar, in patients, who are at high risk for a disabling spasticity it is recommended to start a BoNT therapy early, when early signs like moderate increase in velocity dependend increase in muscle tone (MAS >1+) is present in two joints of the paretic limbs [35]. Goal-oriented management of PS-SMD, including BoNT-A therapy within a few weeks to three months after stroke onset, has shown to prevent or reduce the development of severe or disabling SMD and its complications like finger contractures [2,12]. Considering positive outcomes associated with early BoNT-A therapy, it is strongly recommended to initiate treatments including BoNT-A therapy in the acute to early subacute phase after stroke in patients with existing PS-SMD or at high risk of developing severe PS-SMD, to prevent or reduce post-stroke disability and improve rehabilitation outcome [2,12,42]. This is especially true for BoNT-A injections within 3 months following stroke in patients with beginning PS-SMD or at high risk to develop severe or disabling spasticity as controlled studies with early BoNT-A interventions showed longer endurance of BoNT-A effect with lower dose per muscle compared with doses used in chronic spasticity and reduction in the probability to develop complications like contractures and spasticity-associated pain in the chronic phase after stroke [2,12,42].

In the chronic phase of focal, multi-focal, and segmental PS-SMD BoNT-A injections should primarily target spastic muscles that are either identified to create disability or muscles that already are involved in complications. It should be underlined that therapeutic interventions for severe or disabling PS-SMD should be embedded in a multi-professional team approach that involves a comprehensive patient-centered multi-modal therapy program. This includes e.g., occupational and physical therapy, physical treatments (casting), electrical stimulation, and BoNT-A injections to the targeted spastic muscles [2,3].
Regardless of the fact that the majority of BoNT-A treatment for PS-SMD is done in the chronic-phase after stroke - where spasticity and muscle deformities are already established, it should be noted that there is no restriction for the timing of BoNT-A treatment for any region of the upper and lower limbs based on product licenses.

Degenerative changes in affected spastic muscles

The long-term repeated or chronic use of BoNT-A injections for spasticity management has raised concerns about persistent muscle atrophy and degenerative changes in the affected and treated muscles [49]. Affected spastic muscles naturally undergo degenerative changes, including muscle fiber atrophy, fibrosis, and altered architecture. Based on that information the term “spastic myopathy” has been coined by Gracies [22]. As well repeated BoNT-A injections might cause changes in the muscle and might exacerbate these natural changes through muscle atrophy, fibrosis, and altered muscle fiber composition [49].

Prolonged dis-use from non-use in SP can cause muscle atrophy as well as atrophy from temporary neuromuscular endplate block of BoNT-A, leading to decreased protein synthesis and increased degradation. Chronic denervation resulting from BoNT-A injections may trigger fibrotic changes in spastic muscles via gene expression changes, reduced trophic support, and inflammation, leading to the deposition of collagen and a loss of muscle elasticity. Degenerative changes in spastic muscles could impact to the reduction of functional outcomes including muscle weakness, reduced ROM, and decreased muscle strength and contractile properties. Therefore, one obligation and goal of any rehabilitative therapy such as physical therapy, occupational therapy, and targeted exercise programs, as well as local Botulinum toxin treatment is to prevent from or reduce chronic disability and such chronic changes in the muscle tissue [49].

In conclusion, the benefit of BoNT-A therapy generally outweigh the risk of BoNT use associated degenerative changes in spastic muscles. Regular monitoring and individualized treatments can help to minimize these potential degenerative changes. Further studies in this field are warranted.

CONCLUSION

Early identification of PS-SMD has a key role in the management of PS-SMD. If physical management alone is insufficient to control the SMD with accompanying complications from increasing spastic muscle tone and involuntary phasic and tonic muscle activation, early consideration of additional treatment with BoNT-A in focal, multi-focal and segmental spasticity can help to promote effective neurorehabilitation and to avoid long-term complications. Predictors of PS-SMD, including clinical signs and brain imaging data, are established and are being ready to be applied in clinical practice. The first-line management of focal, multi-focal, and segmental PS-SMD involves comprehensive assessment, goal setting in the MPT, technical guided BoNT-A injections, and a setting of multimodal antispastic measures, e.g., time-adjusted adjunctive therapies like serial casting, taping, or functional electrical stimulation. Following evidence-based recommendations, multi-pattern BoNT-A therapy is safe and effective, with no severe side effects. Overall, BoNT-A treatment in the acute or early subacute phase and chronic phases of stroke can effectively reduce muscle tone and improve both passive and active functions, leading to an improved quality of life, in particular when combined with patient-centered care and multimodal or adjunctive other treatment modalities. Especially, BoNT-A injections within 3 months (early subacute phase) following stroke are strongly recommended in patients with PS-SMD or at its high risk as controlled studies with early BoNT-A interventions showed longer endurance of BoNT-A effect with lower dose per muscle and reduction in the probability to develop complications like contractures and spasticity-associated pain in the chronic phase after stroke.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

17. Li S. Spasticity, motor recovery, and neural plasticity after stroke. Front Neurol 2017;8:120.
Sarcopenic Dysphagia and Simplified Rehabilitation Nutrition Care Process: An Update

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Sarcopenic dysphagia is characterized by weakness of swallowing-related muscles associated with whole-body sarcopenia. As the number of patients with sarcopenia increases with the aging of the world, the number of patients with sarcopenic dysphagia is also increasing. The prevalence of sarcopenic dysphagia is high in the institutionalized older people and in patients hospitalized for pneumonia with dysphagia in acute care hospitals. Prevention, early detection, and intervention of sarcopenic dysphagia with rehabilitation nutrition are essential. The diagnosis of sarcopenic dysphagia is based on skeletal and swallowing muscle strength and muscle mass. A reliable and validated diagnostic algorithm for sarcopenic dysphagia is used. Sarcopenic dysphagia is associated with malnutrition, which leads to mortality and Activities of Daily Living (ADL) decline. The rehabilitation nutrition approach improves swallowing function, nutrition status, and ADL. A combination of aggressive nutrition therapy to improve nutrition status, dysphagia rehabilitation, physical therapy, and other interventions can be effective for sarcopenic dysphagia. The rehabilitation nutrition care process is used to assess and problem solve the patient’s pathology, sarcopenia, and nutrition status. The simplified rehabilitation nutrition care process consists of a nutrition cycle and a rehabilitation cycle, each with five steps: assessment, diagnosis, goal setting, intervention, and monitoring. Nutrition professionals and teams implement the nutrition cycle. Rehabilitation professionals and teams implement the rehabilitation cycle. Both cycles should be done simultaneously. The nutrition diagnosis of undernutrition, overnutrition/obesity, sarcopenia, and goal setting of rehabilitation and body weight are implemented collaboratively.

Keywords: Aging, Deglutition disorders, Frailty, Muscles, Sarcopenia

INTRODUCTION

Sarcopenia, defined as loss of muscle strength, muscle mass, and physical function, is increasing with the aging population [1]. According to the World Health Organization report, the percentage of the world population aged 65 and over is projected to increase from 5% in 1950 to 10% in 2022 and 16% by 2050 [2]. Aging is associated with a wide range of aging phenomena. Handgrip strength increases with age, peaking in the 30s and 40s, then declines thereafter [3,4]. Muscle mass increases with age, then maintains or decreases after the 40s and 50s [3,5,6]. The number of comorbidities increases with age in older people...
Sarcopenic dysphagia is a disorder characterized by a combination of sarcopenia, a decrease in muscle mass and strength, and dysphagia, difficulty in swallowing. Sarcopenia is common in older adults and increases the risk of complications such as pneumonia, malnutrition, and falls. Dysphagia can affect quality of life and lead to poor nutrition status, which can exacerbate sarcopenia. The prevalence of sarcopenic dysphagia increases with age, and it is more common in women than men.

### Diagnostic criteria and screening

Diagnostic criteria for sarcopenic dysphagia are based on loss of skeletal and swallowing-related muscle mass and strength. According to Wakabayashi [36], Diagnostic criteria for sarcopenic dysphagia are as follows: (1) Presence of dysphagia. (2) Presence of whole-body sarcopenia. (3) Results of imaging studies are consistent with loss of swallowing muscle mass. (4) Causes of dysphagia other than sarcopenia are excluded. Ultrasound, computed tomography, and magnetic resonance imaging can evaluate swallowing-related muscle mass. In particular, ultrasound evaluation of the geniohyoid muscle shows good reliability and validity.

The diagnostic flowchart of sarcopenic dysphagia does not include an assessment of swallowing-related muscle mass. Patients 65 years of age and older with no cognitive decline are evaluated and diagnosed for physical function, muscle mass, swallowing function, underlying disease, and strength of swallowing-related muscle. Physical function and total body muscle mass are determined using the diagnostic criteria of...
the European Working Group on Sarcopenia in Older People 2 [10] or the Asian Working Group for Sarcopenia (AWGS) 2019 [43]. The cut-off values for hand grip strength are determined by males≤28 kg, female≤18 kg, or gait speed<1.0 m/sec in the AWGS 2019 diagnostic criteria. Assessment of swallowing function includes the revised Modified Water Swallowing Test, Water Swallowing Test, Food Test, Video Endoscopic Examination of Swallowing, and Video Fluoroscopic Examination of Swallowing. Muscle strength of the swallowing-related muscle is assessed by tongue pressure [44-52]. A diagnosis of probable sarcopenic dysphagia is made if there is muscle weakness in tongue pressure (<20 kPa). If there is no weakness in tongue pressure or if tongue pressure is difficult to measure, a diagnosis of possible sarcopenic dysphagia is made.

Screening for sarcopenic dysphagia includes handgrip strength, calf circumference, or body mass index. The cut-off values were 19.7 kg for handgrip strength in males and 29.5 cm for calf circumference in females [53]. The body mass index cut-off value was 20.1 kg/m² in older dysphagia patients [54]. Early assessment of swallowing function may prevent sarcopenic dysphagia. Therefore, early screening and using the diagnostic flowchart is recommended [13].

**Prevalence**
Sarcopenic dysphagia has a high prevalence among institutionalized older people and patients hospitalized for pneumonia with dysphagia in acute care hospitals. Of 100 sarcopenic seniors aged 65 years and older in nursing homes, 45% had sarcopenic dysphagia [55]. In an acute general hospital, 32% of patients undergoing swallowing rehabilitation had sarcopenic dysphagia [56]. Among patients hospitalized for pneumonia with dysphagia, 81% had sarcopenic dysphagia [57]. Patients with lower skeletal muscle mass and grip strength at baseline <8 kg had a higher incidence of dysphagia at discharge in post-operative hip fracture inpatients [58]. Dysphagia is common in patients with older age, poor performance status, gait disturbance, low body weight, malnutrition, and poorer food intake [59]. Sarcopenic dysphagia in community-dwelling older people is underreported and its prevalence is unknown.

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**Fig. 1.** Diagnostic flowchart of sarcopenic dysphagia. HS, hand grip strength; GS, gait speed; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.
Prognosis
Patients with sarcopenic dysphagia have poor improvement in swallowing function and are prone to malnutrition [60]. In addition, patients with malnutrition have significantly weaker swallowing-related muscles, which can easily lead to a vicious cycle of further deterioration of swallowing function compared to patients with normal nutrition status [61]. Patients with sarcopenic dysphagia have less improvement in swallowing function than patients with non-sarcopenic dysphagia [60]. From a nutritional standpoint, sarcopenic dysphagia is associated with poor improvement in swallowing function because they tend to be malnourished. On the other hand, swallowing function improves better with swallow muscle strengthening interventions in patients with sarcopenic dysphagia compared to patients without sarcopenic dysphagia [62]. From a physiological perspective, targeting the swallowing muscles directly seems effective in improving swallowing function because they do not suffer from damage caused by diseases such as stroke and neck cancer.

Sarcopenic dysphagia is associated with increased mortality and poor ADL improvement in older people. Malnutrition is associated with muscle weakness, wasting, physical frailty, and complications during hospitalization, and impedes improvement in ADL and increases mortality [61,63]. Mortality is 1.4 times higher among older people with sarcopenic dysphagia than among those without dysphagia in care facilities [62]. The risk of death is higher, especially when they are affected by weight loss and malnutrition [64]. Patients with sarcopenic dysphagia tend to have low ADL independence and poor improvement compared to patients with non-sarcopenic dysphagia [60]. Moreover, ADL improvement is significantly lower in malnourished patients compared to those with normal nutrition status.

High levels of inflammation are associated with poor improvement in swallowing function, and C-reactive protein (CRP) may be a prognostic predictor of swallowing function in patients with sarcopenic dysphagia [64]. Mori et al. [64] defined patients with CRP of ≥5.0 mg/L as the high-inflammation group and reported poor improvement in swallowing function in the high-inflammation group compared to the low-inflammation group. Adding the result of CRP levels to the initial assessment of swallowing function could predict the more accurate prognosis.

Treatment and prevention
The combination of aggressive nutrition therapy and rehabilitation can effectively treat sarcopenic dysphagia [13,25]. Aggressive nutrition therapy is nutritional care management that sets goals for total daily energy intake according to daily energy expenditure and daily energy accumulation [35]. Older patients require more than 250 kcal/day of daily energy accumulation to gain 1 kg of body weight per month [65]. A mean provided energy intake of ≥30 kcal/ideal body weight (kg)/day improved swallowing function in older patients with dysphagia, and ADL improved significantly in the patient undergoing rehabilitation in the acute care hospital [66]. Treatment of sarcopenic dysphagia could improve muscle strength and function throughout the body, including the swallowing muscles, by combining aggressive nutrition therapy, dysphagia rehabilitation, and physical interventions such as physical therapy [66-68].

Hospitalized patients need to evaluate and monitored to minimize sarcopenic dysphagia. Hospital-associated sarcopenia and acute sarcopenia are classified into iatrogenic and non-iatrogenic [69]. While prevention of non-iatrogenic sarcopenia is difficult, prevention of iatrogenic sarcopenia caused by the medical activities of health care professionals including doctors, nurses, and others is possible. The combination of rehabilitation, appropriate nutritional management, and medication review from admission may prevent sarcopenia during hospitalization [69].

Early detection and intervention are necessary because older people with presbyphagia are at risk for sarcopenic dysphagia. Presbyphagia is characterized by the fragility of the swallowing mechanism due to age-related changes [70-75]. Presbyphagia in older people could develop into sarcopenic dysphagia because of their disease, activity level, and nutrition status when hospitalized for diseases [36]. Monitoring nutrition status and swallowing function in older people by questionnaire such as the 10-item Eating Assessment Tool and clinical examination may be effective in preventing sarcopenic dysphagia during hospitalization [76-81].

REHABILITATION NUTRITION

Rehabilitation nutrition care process
The rehabilitation nutrition care process is a systematic problem-solving method used to assess the nutrition status, sarcopenia, and nutritional intake of people with disabilities and frail older people [82]. The rehabilitation nutrition care process consists of five steps [83]: (1) rehabilitation nutrition assessment and diagnostic reasoning, (2) rehabilitation nutrition diagnosis, (3) rehabilitation nutrition goal setting, (4) rehabilitation nutri-
tion intervention, and (5) rehabilitation nutrition monitoring. Collaboration between rehabilitation and nutrition helps set appropriate goals and develop appropriate rehabilitation and nutrition care management [26].

The simplified rehabilitation nutrition care process consists of a nutrition cycle and a rehabilitation cycle, each with five steps. Nutrition professionals and teams implement the nutrition cycle (Fig. 2). Rehabilitation professionals and teams implement the rehabilitation cycle. Goal setting is based on diagnostic reasoning about the presence and cause of malnutrition and sarcopenia. In addition, rehabilitation and nutrition professionals should work together to achieve rehabilitation and nutrition goals. The nutrition diagnosis of undernutrition, overnutrition/obesity, sarcopenia, and goal setting of body weight and rehabilitation should be implemented collaboratively. Both cycles should be done simultaneously. The physiatrists can conduct both cycles simultaneously.

Diagnostic reasoning in rehabilitation nutrition
Diagnostic reasoning is the thought process that leads to a diagnosis based on symptoms, laboratory findings, and test results [84]. Diagnostic reasoning is a fundamental skill for healthcare professionals, because the correct diagnosis of a condition leads to the appropriate treatment. Inadequate diagnostic reasoning about nutrition status and sarcopenia would cause an inappropriate rehabilitation nutrition. Therefore, proper diagnostic reasoning is required to provide effective rehabilitation nutrition.

The thought process in diagnostic reasoning consists of non-analytic (intuitive) and analytic reasoning and requires taking advantage of them properly. Non-analytic reasoning is a diagnostic method that quickly understands and recognizes disease patterns based on experience. Intuitive, automatic, and fast are the main attributes of this method, and experienced medical professionals often use it appropriately [85]. However, it is susceptible to bias and carries the risk of misdiagnosis. Analytic reasoning is a logical diagnostic method that is time-consuming and requires more resources than the other [86]. Analytic reasoning is often used by novices with limited clinical experience. Balancing both methods without showing bias toward one or the other is important for proper diagnosis.

Among the various nutritional problems, diagnostic reasoning in rehabilitation nutrition is critical in three of them [84]: causes of anorexia, weight loss, and sarcopenia. The causes of anorexia, weight loss, and sarcopenia are not necessarily a single cause, but rather multiple causes. Therefore, analytical reasoning is recommended in these conditions to infer these causes.

Goal setting in rehabilitation nutrition
Goal setting in rehabilitation nutrition is based on SMART, an effective goal setting method to improve goal attainment [87]. This method recommends incorporating five elements: Specific, Measurable, Achievable, Relevant, and Time-Bound [87]. For example, gaining 2 kg of body weight in one month and being able to walk independently indoors with a walking cane in two weeks are considered SMART goals. Goal setting based on SMART affects the rate of goal attainment. In a study of patients...
with stage 3–4 chronic kidney disease, food intake was higher in the SMART goal-setting group than in the non-SMART goal-setting group [88]. Setting weight goals makes rehabilitation nutrition interventions more appropriate, whether to gain weight in underweight patients or to lose weight in overweight patients. In obese patients undergoing cardiac rehabilitation, setting a weight loss goal results in greater weight loss than not setting a goal [89].

**Aggressive nutrition therapy**

Aggressive nutrition therapy is a nutritional management method for malnutrition [35]. Aggressive nutritional therapy must be combined with active exercise and rehabilitation to increase muscle mass and strength. The target energy intake in this method is defined as the sum of the total energy expenditure and the daily energy accumulation used to gain or lose body weight intentionally. The energy requirements for weight gain in patients with malnutrition and sarcopenia depend on a variety of patient factors, including sex, age, nutrition status, functional status, changes in body composition, contents of exercise, systemic inflammation, and comorbidities.

The energy requirements are set by adding the amount of daily energy accumulation in patients with malnutrition. Older underweight post-stroke patients in convalescent rehabilitation ward require about 9,600 kcal intake to gain 1 kg of body weight [90]. On the other hand, the amount of energy intake is set lower than their actual activity to lose weight in patients with obesity.

The indication and timing of aggressive nutrition therapy depends on the etiology and severity of malnutrition. The efficacy of therapy, side effects, and comorbidities are monitored during the therapy [35]. Aggressive nutritional therapy is planned and implemented based on the four etiologies of the Global Leadership Initiative on Malnutrition criteria (Table 1) [91]. Nutritional intake should be adjusted according to the activity level to prevent malnutrition and maintain physical function and muscle strength in patients with diabetes mellitus. Energy intake and protein are calculated based on kilograms of ideal body weight. Specifically, \( \geq 25–35 \) kcal/kg of energy intake is recommended according to the level of physical activity, and \( \geq 1.0 \) g/kg of protein is required per day [66]. Monitoring is necessary during aggressive nutrition therapy because side effects such as hyperglycemia, dyslipidemia, elevated blood urea nitrogen, liver dysfunction, and electrolyte abnormalities may occur. The frequency of monitoring should be weekly rather than monthly for patients in convalescent rehabilitation wards [35]. Determination of whether to continue or modify aggressive nutrition therapy based on monitoring of function, body weight, fat mass, and muscle mass.

**Nutritional physical therapy**

Nutritional physical therapy was defined by the Nutrition and Swallowing Physical Therapy Committee of the Japanese Physical Therapy Association in September 2017. Nutritional physical therapy is the practice of setting goals based on an understanding of malnutrition, sarcopenia, and excess or deficient nutritional intake to maximize an individual’s function, activity, participation, and quality of life. Therefore, physical therapists should share nutrition and physical therapy assessments with registered dietitians and other multidisciplinary professionals to determine nutritional care management and physical therapy.

**Table 1. Indication/timing/contraindication of aggressive nutrition therapy**

<table>
<thead>
<tr>
<th>No.</th>
<th>Indication</th>
<th>Timing</th>
<th>Contraindication</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Cancer</td>
<td>Pre cachexia</td>
<td>Refractory cachexia</td>
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<tr>
<td></td>
<td>Chronic obstructive pulmonary disease</td>
<td>Cachexia</td>
<td></td>
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<tr>
<td></td>
<td>Congestive heart failure</td>
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<td></td>
<td>Chronic kidney disease</td>
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<tr>
<td>2</td>
<td>Anorexia nervosa</td>
<td>Short bowel syndrome</td>
<td>Severe dementia</td>
</tr>
<tr>
<td></td>
<td>Short bowel syndrome</td>
<td>Mild to moderate dementia</td>
<td>Bedridden</td>
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<td></td>
<td>Stroke</td>
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<td></td>
<td>Amyotrophic lateral sclerosis</td>
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<td></td>
<td>Dementia</td>
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<tr>
<td>3</td>
<td>Major infection</td>
<td>Mildly invasive disease and transition to the anabolic phase</td>
<td>Acute disease or injuries with severe inflammation</td>
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<td></td>
<td>Burns</td>
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<td>Trauma</td>
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<td></td>
<td>Closed head injury</td>
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<tr>
<td>4</td>
<td>Starvation</td>
<td>No symptoms or risks for refeeding syndrome</td>
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that takes into account activity level, muscle tone, and involuntary movements [30].

Nutritional physical therapy overlaps with rehabilitation nutrition, and the two concepts share goals, assessment, and intervention strategies. The practice of these two concepts requires both perspectives [30]: physical therapy that considers nutrition status and nutritional care management that maximizes the effectiveness of physical therapy. Exercise therapy consists of flexibility exercises, resistance training, and aerobic training. Flexibility exercises are prescribed for patients with any nutritional condition. Patients with nutritional deficiencies should receive low-intensity exercise to maintain physical function. In contrast, patients with adequate nutrition should receive moderate or higher intensity exercise to improve physical function. Exercise load settings are determined using subjective exercise intensity (Borg scale) and other factors, and exercise frequency, intensity, and duration are adjusted. Exercise and nutrition therapy are effective, however few reports exist on the effectiveness of nutritional physiotherapy [30]. In addition, systematic clinical practice based on a bi-directional nutrition and physical therapy perspective is limited. Further clinical practice and studies of nutritional physical therapy are needed.

**CONCLUSION**

Sarcopenic dysphagia reduces swallowing function, ADL and life prognosis. The triad of rehabilitation, nutrition, and oral management may be useful for patients with dysphagia [92]. The triad of rehabilitation, nutrition and oral management requires a multimodal approach based on collaboration among different professions, institutions, and communities. Prevention of whole-body sarcopenia is the priority for sarcopenic dysphagia, and early diagnosis and treatment of sarcopenic dysphagia are essential. However, the use of tools diagnose sarcopenic dysphagia is inconsistent and heterogeneous, and validation against objective measures of swallowing dysfunction is limited [93]. A review of diagnostic criteria and the development of clinical practice guidelines for sarcopenic dysphagia are needed. The development of evidence on the simplified rehabilitation nutrition care process is required.

**CONFLICTS OF INTEREST**

No potential conflict of interest relevant to this article was reported.

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None.

**AUTHOR CONTRIBUTION**

Conceptualization: Wakabayashi H. Methodology: Wakabayashi H, Kakehi S. Formal analysis: all authors. Project administration: Wakabayashi H. Kakehi S. Visualization: Wakabayashi H, Ninomiya J, Shioya M. Writing – original draft: all authors. Writing – review and editing: Wakabayashi H, Kakehi S, Isono E. Approval of final manuscript: all authors.

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**REFERENCES**

5. Yamada M, Moriguch Y, Mitani T, Aoyama T, Arai H. Age-depen-


55. Wakabayashi H, Takahashi R, Murakami T. The prevalence and


82. Mizuno S, Wakabayashi H, Wada E. Rehabilitation nutrition for individuals with frailty, disability, sarcopenic dysphagia, or sarcopenic
INTRODUCTION

Frailty and sarcopenia are critical topics in geriatric healthcare. These two conditions are major contributors to the decline in health and function in older adults. Frailty represents a vulnerability resulting from a decline in physical, cognitive, and social functioning, which makes it difficult to maintain healthy aging. Frailty is diagnosed as positive when three or more of the following five criteria are met: unintentional weight loss, self-reported exhaustion, weakness, slow walking speed, and low physical activity level. This vulnerability increases the likelihood of hospitalization due to events such as infections, acute illnesses,
and traffic accidents and prolongs recovery periods after acute illnesses [1].

Sarcopenia, a problem resulting from a loss of muscle mass and function, also impairs functional ability and reduces quality of life (QoL) in older adults. The European Working Group on Sarcopenia in Older People 2 defines sarcopenia primarily by low muscle strength in handgrip strength (cut-off points for male<27 kg and female<16 kg) and chair stand (cut-off points; >15 seconds for five rises). To confirm the diagnosis of sarcopenia, low muscle quantity or quality is required as measured by magnetic resonance imaging, computed tomography, or dual-energy X-ray absorptiometry. Severe sarcopenia is identified by concurrent low muscle strength, quantity/quality, and reduced physical performance, as assessed by tests such as the Short Physical Performance Battery, gait speed, the 400 m walk test, or the Timed Up and Go Test [2]. It makes it difficult for older adults to perform daily activities and increases the risk of mobility impairment and falls. Additionally, sarcopenia is associated with metabolic disorders, cardiovascular diseases, and Alzheimer’s disease, which increases the risk of developing such diseases [3].

Therefore, preventing and managing frailty and sarcopenia in geriatric healthcare is essential. This requires the use of various approaches, such as physical activity, nutrition, cognitive and social engagement, to maintain and improve older adults' health and function. Regular health checkups are also necessary to continually manage older adults' health [4].

The use of e-Health interventions in healthcare has become increasingly popular over the years. E-Health interventions refer to the use of digital technologies such as mobile apps, websites, wearable devices, and telemedicine to provide healthcare services remotely [5]. In the context of older adults with sarcopenia or frailty, e-Health interventions have the potential to address several challenges, including access to healthcare services, physical limitations, and social isolation [6]. However, older adults with sarcopenia or frailty may have difficulties participating in traditional exercise programs due to physical limitations, mobility issues, or a lack of access to resources. E-Health interventions can potentially address some of these barriers by providing personalized and adaptable exercise programs, remote monitoring and support, and social connections through virtual communities.

So, our study hypothesis is that e-Health interventions have the potential to increase physical activity and performance in older adults with sarcopenia or frailty. Previous studies suggest that e-Health could potentially improve rehabilitation outcomes for the elderly [7]. Various e-Health have shown a significant overall positive effect on strength and physical fitness in the elderly. However, the efficacy of e-Health on strength and physical fitness in the elderly with sarcopenia or frailty has not been established. This study aimed to systematically review the efficacy of e-Health interventions on physical performance, activity, and QoL in older adults with sarcopenia or frailty.

METHODS

Protocol and registration

The protocol for this systematic review was registered in PROSPERO (https://www.crd.york.ac.uk/PROSPERO). The registration number is CRD42022315152. This systematic review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) statement guidelines. The completed PRISMA 2020 checklist is shown in Supplementary Materials S1 and S2.

Criteria for this review (PICO)

(1) Participants (P): Aged population (over 65) with sarcopenia OR muscle atrophy OR frailty.

(2) Intervention (I): E-Health OR telemedicine OR web-based intervention.

(3) Comparison (C): No intervention.


Criteria for considering the studies in this review

We included randomized controlled trials (RCTs) of the effects of e-Health on the elderly population (over 65) with sarcopenia, muscle atrophy, or frailty published in English. The types of interventions are e-Health, telemedicine, or web-based interventions. The types of comparators are no intervention. Exclusion criteria included: (1) full text is not available; (2) literatures includes diseases other than sarcopenia or frailty; (3) literatures does not include outcome parameters; and (4) duplicate publications.

Search strategies and data resources

We searched the MEDLINE, Embase, Cochrane Library, CINHAL, Web of Science, and the Physiotherapy Evidence Database (PEDro) for experimental studies published in English.
from 1990 to 2021, to obtain RCTs that studied the efficacy of e-Health for older adults with frailty or sarcopenia. The following key search terms were used: “Frailty,” “muscle atrophy,” and “sarcopenia.” The full search strategies, which were tailored according to the characteristics of the databases mentioned previously, are listed in Supplementary Material S3. We then manually searched the gray literature, reference lists of identified studies, MEDLINE, Embase, CINHAL, Web of Science, and PEDro for eligible RCTs.

**Reviewing procedure and study selection**

Two reviewers independently identified eligible studies according to inclusion and exclusion criteria. After removing duplicates, primary selection was performed based on titles and abstracts. Then, titles, abstracts, and potentially relevant full texts were thoroughly reviewed according to eligible criteria by six reviewers, and any disagreements were resolved by discussion. (1) Study population must be geriatric patients (defined as above 65 years old). (2) Study must have implemented a method for randomization. (3) Study must include outcome measures of muscle mass or functional outcome.

**Data extraction**

Data extraction was performed in the inclusion study. Data were extracted by two reviewers, including study design, participants, intervention type, outcome measures, and results. A cross-check was performed to ensure no mistakes.

**Methodological quality assessment**

Two reviewers independently assessed the risk of bias of each included study by using the revised Cochrane risk of bias tool for individually randomized trials. Discrepancies were resolved through a team discussion.

**Data synthesis and analysis**

We presented results as an effect with a standardized mean difference (SMD), and 95% confidence interval (95% CI) for continuous data and an odds ratio (OR), and 95% CI for binary data. Egger’s test was performed to check for publication bias. The heterogeneity across studies was assessed using Cochrane’s Q-test and I²-statistic. The random effects model was used for the meta-analysis. Meta-analysis was performed using Stata/MP version 16 (StataCorp LLC).

**RESULTS**

**Literature flow**

Overall, 3,164 publications were identified, and after the exclusion of duplicates, 3,002 articles remained. Of these, 2,951 were excluded, leaving 51 publications for potential inclusion. Of these, after applying the eligibility criteria, 47 were selected for full-text reading, after which a total of 4 articles were selected (Fig. 1). We could not find any studies related to sarcopenia, and studies related to frailty were included in this review.

**Study characteristics**

Table 1 summarizes the characteristics and main results of the 4 articles. Across all studies, the minimum age was 60 years, and the earliest year of data collection was 2007 [8-11].

**Participants**

In total, 380 participants were enrolled in the included studies, 187 in the intervention group (IG) and 193 in the control group (CG). Two studies recruited only male or female participants. Peterson et al. [8] recruited participants aged 70 and over (age, 78.4±4.9 years), and eighty-one elderly male veterans were...
randomized to intervention (n=39) or combined CGs (n=42). In the study of Vestergaard et al. [9], community-dwelling frail female≥75 years old, receiving public home care were randomized into a training group (n=30, age, 81.0±3.3 years) and a CG (n=31, age, 82.7±3.8 years). Other studies recruited both sexes. Upatising et al. [10] enrolled 205 adults aged 60 years or older (n=205, age, 80.4±8.3 years) with a high risk of hospitalization and emergency department visits (Elder Risk Assessment score of 16 or higher). Kwan et al. [11] recruited 33 adults aged ≥60 years (n=33, age, 71.0±9 years) with cognitive frailty and physical inactivity.

**Interventions**

The e-Health interventions used in the selected articles were telephone exercise counseling, home-based video exercise intervention, telemonitoring case management, and mobile health (mhealth) intervention (i.e., smartphone-assisted programs using WhatsApp [Meta Platforms] and Samsung Health [Samsung Electronics]). The detailed interventions of each article are as follows. In the study of Peterson et al. [8], date, length, and specific exercise data for contact with the health care counselor were collected at the time of the call and recorded into the database. The health counselor followed up with phone calls once a month for the first three months and twice a week for the remaining 3 months. Vestergaard et al. [9] provided all participants in the IG with a 30-minute video tape showing a booklet describing them, exercises, and an elastic resistance band. The IG exercised at home for 26 minutes, three times a week, for five months. In Upatising et al. [10], the telemonitoring process entailed installing the Intel® health guide, in addition to other peripheral devices, within the patient’s residence and establishing a connection to the healthcare system through a broadband network. The primary outcome at 6 months compared with baseline and at 12 months compared with 6 months. Kwan et al. [11] used a mobile phone application. Samsung Health is a physical activity autotracking app, and it continuously and autonomously monitors the walking patterns (e.g., steps, walking speed, walking time, physical activity intensity) of the users. The total duration

**Table 1. Characteristics and main results of the studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants (IG/CG) sample</th>
<th>Interventions</th>
<th>Outcome measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peterson et al., 2007</td>
<td>N=81 (39/42)</td>
<td>Telephone exercise counseling: follow-up telephone calls</td>
<td>Physical activity</td>
<td>In the IG, the proportion of frail was reduced by 18% over 6 months</td>
</tr>
<tr>
<td></td>
<td>Male veterans, ages 70</td>
<td>biweekly for 3 months and once a month for the remaining</td>
<td>Physical performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and over</td>
<td>3 months</td>
<td>Frailty status</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean age: 78.4±4.9 yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vestergaard et al., 2008</td>
<td>N=61 (30/31)</td>
<td>Home-based video exercise intervention: three times a week,</td>
<td>Hand-grip strength (kg)</td>
<td>Significant improvements in handgrip strength by 17.1% in the IG</td>
</tr>
<tr>
<td></td>
<td>Frail female≥75 yr</td>
<td>for five months, 60 exercise sessions</td>
<td>Functional ability measurements</td>
<td>Significant difference in the changes observed in the IG and CG in EQ-5D</td>
</tr>
<tr>
<td></td>
<td>IG mean age: 81.0±3.3 yr</td>
<td></td>
<td>Physical performance test</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CG mean age: 82.7±3.8 yr</td>
<td></td>
<td>EQ-5D (score)</td>
<td></td>
</tr>
<tr>
<td>Upatising et al., 2013</td>
<td>N=205 (102/103)</td>
<td>Telemoitoring case management: for 12 months follow-up</td>
<td>Fried frailty criteria</td>
<td>No significant increase in functional decline during the first six months (OR, 1.41; 95% CI, 0.65–3.06; p=0.38) and the latter six months (OR, 5.94; 95% CI, 0.52–68.48; p=0.15)</td>
</tr>
<tr>
<td></td>
<td>Aged 60 years or older with</td>
<td></td>
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<tr>
<td></td>
<td>an ERA score of 16 or higher</td>
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</tr>
<tr>
<td></td>
<td>Mean age: 80.4±8.3 yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kwan et al., 2020</td>
<td>N=33 (16/17)</td>
<td>mHealth Intervention: The total intervention period</td>
<td>Hand-grip strength (kg)</td>
<td>Handgrip strength: improvement was significant in the IGs (p=0.009).</td>
</tr>
<tr>
<td></td>
<td>Age ≥60 years, having</td>
<td>lasted for 12 weeks</td>
<td>MVPA time (min/wk)</td>
<td>MVPA time (median difference 86 min/wk, p=0.04; median difference 18.5</td>
</tr>
<tr>
<td></td>
<td>cognitive frailty, and</td>
<td></td>
<td></td>
<td>min/valid day, p=0.02) increased significantly after the intervention in the IG only</td>
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<tr>
<td></td>
<td>having physical inactivity</td>
<td></td>
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<tr>
<td></td>
<td>Mean age: 71.0±9 yr</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Values are presented as mean±standard deviation.

IG, intervention group; CG, control group; EQ-5D, EuroQol five-dimension scale questionnaire; ERA, Elder Risk Assessment; OR, odds ratio; 95% CI, 95% confidence interval; MVPA, Moderate to Vigorous Physical Activity.
of the intervention as a whole was 12 weeks.

**Risk of bias assessment**

According to the Cochrane risk of bias tool, all studies had a high risk of bias in the blinding of participants and personnel. One study had an unclear risk of bias in the allocation concealment. Half of the studies were had a risk of blinding of outcome assessment. All other bias categories had low risk of bias (Fig. 2).

**Main outcome**

**Physical activity**

Kwan et al. [11] examined physical activity with the Physical Activity Scale of Elderly and Moderate to Vigorous Physical Activity (MVPA) time (min/week) analysing 16 participants in the IG and 17 participants in the CG. In this study, MVPA time (median difference 86 min/week, p=0.04; median difference 18.5 min/valid day, p=0.02) significantly increased after the intervention in the IG only.

**Physical performance**

Vestergaard et al. [9] and Kwan et al. [11] examined physical performance with walking speed analysing 38 participants in the IG and 39 participants in the CG. In Vestergaard et al. [9], the IG significantly improved maximum walking speed by 8.2% (p=0.049), whereas the CG showed a significantly improved maximum walking speed of 7.4% (p=0.038).

Vestergaard et al. [9] and Kwan et al. [11] examined physical performance with hand grip strength (kg) analysing 40 participants in the IG and 43 participants in the CG. Within-group analysis showed significant improvements in handgrip strength by 17.1% in the IG, whereas no improvement was observed in the CG [9]. The forest plot showed that IG groups showed improvement after intervention, and no heterogeneity was noted (SMD, 0.51; 95% CI, 0.07–0.94; p=0.80, I^2=0%; Fig. 3).

For both of the above outcomes, the publication bias could not be analyzed because there were two papers to be analyzed.

**Frailty status**

Peterson et al. [8] and Upatising et al. [10] examined frailty status with Fried frailty criteria analysing 68 participants in the IG and 81 participants in the CG. Peterson et al. [8] found that almost 70% of the participants were frail at baseline. In the IG, the proportion of frailty was reduced by 18% over 6 months, whereas there was no change in proportion over time in the CG. Upatising et al. [10] did not provide sufficient evidence to show that the telemonitoring group did better than usual care in decreasing the decline of frailty states and death. The forest plot showed that both groups had similar values (OR, 0.80; 95% CI, 0.26–2.53; p=0.04; I^2=77.39%). A publication bias was observed (Egger’s test, p=0.035; Fig. 4).

**Additional outcome**

**QoL**

Vestergaard et al. [9] examined QoL with EuroQol five-dimension scale questionnaire (EQ-5D), EQ visual analogue scale score, and S-R health analysing 24 participants in the IG and 27 participants in the CG. In this study, using an exercise video induced lasting health-related QoL (EQ-5D). In addition, im-

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**Fig. 2.** The Cochrane Collaboration’s tool for assessing the risk of bias in the included studies.
Improvements in physiological performance and functional capacity were generally observed [9].

**DISCUSSION**

In this systematic review and meta-analysis, we originally attempted to review RCTs of e-Health interventions for sarcopenia but could not find any. As a result, studies on frailty were included in the analysis, and we found insufficient evidence to support or oppose the efficacy of e-Health interventions on outcomes. Nevertheless, the studies included in this review showed positive effects of e-Health interventions on improving muscle strength, QoL, and physical activity in older adults with frailty or high risk. Two studies used frailty status as an outcome measure and showed conflicting results. Muscle strength was assessed in two studies, and a meta-analysis showed statistically significant improvement after intervention. Individual studies reported significant improvements in QoL and physical activity.

In another systematic review published recently, Esfandiari et al. [12] analyzed the effect of e-Health interventions on function and QoL for older adults with frailty. They analyzed data from 12 RCTs and found low evidence of benefits for telehealth interventions on function and the mental component of QoL. The effect of mHealth app interventions on sedentary time, physical activity and fitness in older adults (aged 55 years and older) was investigated in another systematic review by Yerrakalva et al. [13]. The review included six studies and found that mHealth app interventions may be effective in reducing sedentary time, increasing physical activity and improving fitness in the short term, but the results did not have a statistical significance. These reviews included more studies than ours due to different selection criteria, but their conclusions are consistent with ours.

The e-Health interventions used in the studies included in our review were various and not standardized. Earlier studies used only telephones [8] and videotapes [9] to encourage exercise. Upatising et al. [10] utilized broadband-based telemonitoring in addition to personal visits. Kwan et al. [11] introduced mobile technology to monitor and encourage exercise and give...
feedback. E-Health interventions can offer several strategies to encourage physical activity, including tailored exercise programs, virtual coaching and feedback, monitoring and tracking, social support, and gamification techniques, which have shown promise in improving physical activity levels in older adults. However, these advantages were not fully adopted in any of the studies included in this review [14,15]. This calls for future research.

The most notable e-Health intervention among the studies in this review is the one conducted by Kwan et al. [11]. According to Kwan et al. [11], older adults’ levels of physical activity have increased by using mHealth activities. When considering the advantages of using a mobile phone over other forms of telerehabilitation, several key points emerge. Mobile phones have become ubiquitous, and a significant portion of the population owns smartphones and utilizes health-related applications. This widespread adoption of mobile technology makes it a convenient and accessible platform for delivering telerehabilitation services. And mobile phones offer a versatile and portable solution, enabling individuals to access therapy services anytime and anywhere, provided they have an internet connection. This flexibility promotes continuity of care and empowers patients to engage in rehabilitation exercises and activities conveniently. Moreover, mobile phones can support a range of multimedia capabilities, such as audio and visual communication, which are vital for effective telerehabilitation. Lastly, the use of mobile phones for telerehabilitation allows for personalized interactions and interventions through applications designed for healthcare professionals, medical students, patients, and the general public. These applications can provide tailored exercise programs, reminders, progress tracking, and educational resources, enhancing patient engagement and adherence to treatment plans. Their benefits, particularly in telerehabilitation, make them a powerful tool for delivering accessible, convenient, and personalized rehabilitation services.

The efficacy of e-Health in different populations has been reported by several studies. In one study, the effectiveness of a smartphone-based home care model for increasing the use of cardiac rehabilitation in myocardial infarction patients was evaluated. The study found that patients who used the smartphone-based home care model were more likely to complete their cardiac rehabilitation program and had better adherence to medication and lifestyle changes compared to those who received standard care. The study suggests that smartphone-based home care models may be a useful tool for improving the management of post-myocardial infarction patients [16]. Another study reported a pilot pragmatic RCT that evaluated how a mHealth app affected physical fitness and functional movement. Healthy male and female between the ages of 18 and 50 who could read and write English and who had a mobile phone that could download apps from the Apple App Store or Google Play Store were eligible to participate in the study. They were randomized to either an IG that utilized a mHealth app to track and monitor their physical activity or a CG that received standard care. According to the study, the IG significantly improved over the CG in functional movement and physical fitness. The authors conclude that the use of a mHealth app may be a useful tool for improving physical activity levels and functional movement in individuals [17]. Also, efficacy in a healthy geriatric population has been reported in several studies. Recent systematic reviews have demonstrated that eHealth interventions are successful at motivating elderly people (age>50 years) to exercise [18]. A healthy lifestyle is essential for reducing the prevalence of morbidity, functional restrictions, and impairment in older adults [19,20], increasing life expectancy, and enhancing overall QoL [21-23].

E-Health interventions are gaining more attention and importance, especially in the current post-pandemic era. A systematic review demonstrated the efficacy of telerehabilitation for patients experiencing disability due to coronavirus disease 2019 (COVID-19). The article’s key message was that physical activity should be given to those who have limited mobility as a result of isolation or lockdown in order to decrease their risk of developing frailty, sarcopenia, cognitive decline, and depression [24]. A clinical trial included in the systematic review introduced a telerehabilitation program in which the participants used either an internet-based platform or an application installed on their mobile phones. The platform allowed the physical therapist to adjust the number of sets, repetitions, speed, and observations for each patient. Therapeutic exercises were delivered in the form of an educational video with a detailed description. Through educational movies, the therapeutic education recommendations were explained to the patients, giving them health and emotional advice on how to improve their QoL after COVID-19. They reported that telerehabilitation led to a clinical improvement in QoL, particularly in the physical component [25]. These interventions can provide individuals with access to rehabilitation programs in the comfort of their own homes. E-Health interventions can be a useful alternative for improving frailty and sarcopenia in older adults, particularly...
during times of restricted mobility. In the future, the increased utilization of these interventions has the potential to enhance accessibility to rehabilitation programs for individuals in the convenience of their own homes, thereby improving their ability to maintain function and independence as they age. In one study [26], for hospitalized frail patients, the “VIVIFRAIL” multicomponent physical activity program was introduced [27]. This program consists of functional unsupervised exercises as well as supervised progressive resistance, balance, and walking exercises. Through the use of e-Health, patients can have access to such exercise programs and other healthcare services from the comfort of their homes, and the barriers to care for those who may have transportation or mobility issues or who live far away from specialists or clinics can be reduced. Additionally, e-Health can provide cost savings and convenience for both patients and healthcare providers [28]. By integrating exercise programs into e-Health platforms, patients can receive personalized exercise plans and have their progress monitored remotely by healthcare professionals, improving overall healthcare outcomes.

E-Health interventions can also be adopted for monitoring various aspects of patient information, such as nutrition and sleep quality, in addition to physical activities, for the purpose of improving frailty in older adults. E-Health can facilitate remote assessment and monitoring in multiple ways, provide personalized exercise programs, and offer virtual coaching and feedback [29]. The development of frailty in older persons is influenced by a number of significant modifiable factors, including nutrition [30]. And poor subjective sleep quality, various sleep symptoms, and longer sleep duration were found to increase the risk of frailty and even pre-frailty in an elderly population aged 70 to 84 years [31]. To manage these problems, an e-Health platform could provide information and resources on nutrition or sleep quality. One study showed a technique was developed and validated to assess pre-frailty risk in human activity patterns based on multimodal biomarkers, such as sleep duration, daily steps, and resting heart rate, collected from smartwatch sensors. Specialized care. So, it could monitor sleep quality and provide feedback on how to improve sleep habits, which may help reduce the risk of frailty [32]. Additionally, researchers and practitioners can use motion sensors mounted on the upper limbs (i.e., lower arm/ wrist, upper arm) to evaluate dietary intake and eating behavior in both laboratory and free-living conditions by using wearable sensing technology (e.g., commercial inertial sensors, fitness bands, and smart watches) [33]. To know what kind of food and how much to eat, there is a study that uses data from people wearing audio and motion sensors along with ground truth from continuous-scale video and data [34]. Another study effectively used a mobile phone image-based nutritional evaluation tool to help people with type 2 diabetes lose weight [35]. In frailty patients, for whom protein and calcium intake are important, monitoring these through e-Health seems to be of great help in nutritional management. However, to improve the adherence of e-Health programs in frailty patients, additional research is required to identify the optimal interventions as well as the best delivery methods and technologies [36].

Protecting the privacy and security of patient information is critical in the digital era of e-Health. This is because unauthorized access and potential breaches in the virtual healthcare realm pose significantly higher risks. Cryptographic techniques, such as The Public Key Infrastructure, are essential to protect sensitive data. This method is additionally reinforced by the inclusion of biometric techniques. By utilizing distinctive individual traits like fingerprints or retina scans, biometric systems add a layer of security by guaranteeing that access is given only on the basis of physiological or behavioral characteristics. Additionally, it is essential to implement multi-factor authentication requiring several verifications prior to accessing the data and regular security audits. These thorough checks will ensure that the e-Health platforms are secure and safety [37,38].

There are several limitations in this systematic review. First, despite the growing interest in e-Health and telerehabilitation, there is still a lack of research on their effectiveness in improving frailty in older adults. Due to this limitation, only a few studies on this topic were included in our review. Second, the e-Health interventions in the four included studies were diverse and could not be standardized. More research is needed to better define effective e-Health measures for elderly population. Third, we found considerable heterogeneity among studies, stemming from diverse methodologies and outcomes, notably complicates our ability to draw cohesive conclusions. The specific criteria, settings, and population characteristics of these studies limit the generalizability of our findings to broader contexts. Thus, further research, emphasizing larger samples and consistent methodologies, is essential to advance our understanding.

Despite these limitations, our review suggests that e-Health may have a positive effect on frailty in older adults. Therefore, further research is necessary to determine the most effective e-Health interventions and understand their mechanisms of
action. By addressing these issues, we can improve the quality of care for older adults with frailty or sarcopenia and promote healthy aging.

**CONFLICTS OF INTEREST**

No potential conflict of interest relevant to this article was reported.

**FUNDING INFORMATION**

None.

**AUTHOR CONTRIBUTION**

Conceptualization: Han HW, Park SW, Kim D. Methodology: Park SW, Kim DY. Formal analysis: Yang YJ. Writing – original draft: Han HW. Writing – review and editing: Park SW, Lee BS, Jeon N. Approval of final manuscript: all authors.

**SUPPLEMENTARY MATERIALS**

Supplementary materials can be found via https://doi.org/10.5535/arm.23090.

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**REFERENCES**

Improved Muscle Mass and Function With Protein Supplementation in Older Adults With Sarcopenia: A Meta-Analysis

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Objective: To systematically review the effects of protein supplementation in older adults with sarcopenia.

Methods: A systematic literature search was conducted in PubMed, Cochrane Library, and Embase databases until May 2023. The inclusion criteria were as follows: (1) randomized controlled trials with a quantitative study design; (2) studies with a study group of older adults with sarcopenia; (3) studies comparing muscle mass, muscle strength, and performance of older adults with sarcopenia after protein supplementation; and (4) studies published up to May 2023.

Results: Six retrospective comparative studies, including 715 patients, met the inclusion criteria. The nutritional supplementation group exhibited significant improvement in appendicular skeletal muscle mass (standardized mean difference [SMD]=0.41; 95% confidence interval [CI], 0.24–0.58; p<0.001; I²=1%), while handgrip strength (SMD=0.37; 95% CI, -0.32–1.07; p=0.29; I²=94%) and Short Physical Performance Battery (SPPB) (SMD=0.35; 95% CI, -0.47–1.18; p=0.40; I²=94%) showed a tendency for improvement.

Conclusion: Nutritional supplementation with protein increased appendicular muscle mass in older adults with sarcopenia and improved handgrip strength and SPPB scores.

Keywords: Sarcopenia, Protein, Skeletal muscle, Meta-analysis

INTRODUCTION

Age-related muscle attenuation, termed “sarcopenia,” contributes to muscle weakness and impaired physical mobility. Sarcopenia and frailty are multidimensional syndromes characterized by a decreased reserve and diminished resistance to stressors [1,2]. Criteria for classifying older adults as having sarcopenia or high frailty risk have recently been established. In 2019, the Asian Working Group for Sarcopenia (AWGS) defined sarcopenia as “age-related loss of muscle mass, plus low muscle strength, or low physical performance.” It proposed diagnostic cut-offs for each component [3]. Low muscle strength is a handgrip strength of <28 kg for male and <18 kg for female. The criteria for low physical performance are a 6-minute walk test slower than 1.0 m/s, a Short Physical Performance Battery (SPPB) score of ≤9, or a 5-time chair stand test of ≥12 seconds. Cut-offs for height-adjusted muscle mass through dual-energy X-ray absorptiometry were <7.0 kg/m² in male and <5.4 kg/m².
in female and that through bioimpedance were $<7.0 \text{ kg/m}^2$ in male and $<5.7 \text{ kg/m}^2$ in female. Sarcopenia in older adults can be devastating, resulting in several adverse events, including increased risk for falls, impaired mobility, elderly depression, increased healthcare costs, and mortality [4,5].

Previous studies report that oral nutritional supplementation improves body composition and decreases functional disability. Among nutritional supplements, high-quality protein or amino acid supplementation is important for preventing a decrease in muscle mass. Whey protein stimulates postprandial muscle protein accretion more effectively than do casein or casein hydrolysate in older people [6]. Whey protein is a rapidly digested dietary protein beneficial for slowing muscle loss, particularly in older adults. When protein or amino acid intake is supplemented, the amount of synthesized muscle protein exceeds the amount broken down [7]. Sufficient protein intake is crucial to maintain muscle mass and function in older adults. The PROT-AGE study group recommended at least 1.0–1.2 g protein/kg/day to maintain and increase muscle mass and function in individuals aged older than 65 years. A higher protein intake (>1.2 g/kg/day) is advised for those who regularly exercise and for community-dwelling older adults [8].

Previous systematic reviews and meta-analysis were limited to parameters related to muscle mass and investigated whether nutritional supplementation could improve muscle mass in older populations [9]. Few meta-analysis of the functional outcomes of nutritional supplementation in older adults with sarcopenia have been conducted. The meta-analysis on the effect of nutritional supplementation on elderly sarcopenia needs an update since several randomized controlled trials (RCTs) have been published after the previous meta-analysis. The management of sarcopenia should focus on increasing muscle mass and functional improvements to eventually prevent the progression of sarcopenia. This study aimed to conduct a focused meta-analysis of studies that used nutritional interventions with a protein- or amino acid-enriched formula in older adults with sarcopenia.

**METHODS**

**Design**
This meta-analysis was conducted according to the guidelines recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (Supplementary Material) [10].

**Literature search and study selection**
The search was performed using PubMed, Cochrane Library, and Embase databases from inception to May 2023 using the following keywords: "older adults" AND "sarcopenia" AND "protein" OR "nutrition" AND "supplement" OR "muscle mass" OR "muscle strength" AND "short physical performance battery."

**Inclusion and exclusion criteria**
Studies were included if they satisfied all of the following selection criteria: (1) RCTs with a quantitative study design; (2) studies with a group of older adults (age ≥65 years) with sarcopenia; (3) studies comparing muscle mass, muscle strength, and functional performance of older adults with sarcopenia after receiving adequate protein supplementation; (4) the supplement intervention used protein sources, including whey protein or leucine, vitamins, and other nutrients; and (5) studies published up to May 2023. Studies published as case reports, case series, or prospectively designed trials without comparison groups were excluded from the analysis.

**Analysis and data extraction**
Data were extracted from each included study and are presented in an evidence table (Table 1) outlining the characteristics of the respective study designs and participants (group design, age, and sex), body composition assessment methods (bioimpedance analysis or dual-energy X-ray absorptiometry), the composition of nutritional supplements, follow-up period, and main measured outcomes [11-16].

Six studies compared older individuals with sarcopenia using diagnostic criteria proposed by the AWGS as quantitative values between the group with nutritional support and the group with placebo. These studies compared muscle mass, muscle strength, and functional performance, including at least two of the following: appendicular skeletal muscle mass (ASM), handgrip strength, and SPPB score, after receiving adequate protein supplementation.

**Statistical analysis**
We separately computed the effect sizes for each study for the primary and secondary outcome measures. The R metapackage was used for statistical analysis and graphics (http://www.r-project.org). The heterogeneity of the studies was calculated using the I² test to observe variations across studies and was estimated to be significant when $p<0.05$. The 95% confidence interval (CI)
<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>Group</th>
<th>Age (yr)</th>
<th>Sex (female/male)</th>
<th>Body composition assessment method</th>
<th>Intervention (nutritional supplementation/exercise)</th>
<th>Follow-up period</th>
<th>Measured outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amasene et al., 2021 [11]</td>
<td>Randomized controlled trial</td>
<td>Intervention (N=21)</td>
<td>82.9±5.67</td>
<td>12/9</td>
<td>DXA</td>
<td>20 g of whey protein isolate enriched with 3 g of leucine, Supervised resistance training (3 times a week)</td>
<td>12 wk</td>
<td>ASM, hand grip strength, SPPB (balance, gait speed, chair stand), weight, BMI, calf circumference, body fat, lean mass, fat-free mass and bone mass, myostatin, follistatin, irisin</td>
</tr>
<tr>
<td>Peng et al., 2022 [12]</td>
<td>Randomized controlled trial</td>
<td>Intervention (N=12)</td>
<td>67.1±6.7</td>
<td>8/4</td>
<td>DXA</td>
<td>Leucine 1 g, arginine 1.5 g, Vitamin D3 7.5 μg, chondroitin 400 mg, glucosamine 700 mg, and calcium 300 mg twice a day</td>
<td>12 wk</td>
<td>ASM, hand grip strength, SPPB, MMSE Serum levels of the total protein, albumin, hepatic and renal function tests, blood lipids, glucose, insulin, HbA1c, electrolytes, and hS-CRP, 25-hydroxyvitamin D</td>
</tr>
<tr>
<td>Bauer et al., 2015 [13]</td>
<td>Randomized controlled trial</td>
<td>Intervention (N=184)</td>
<td>77.3±6.7</td>
<td>120/64</td>
<td>DXA</td>
<td>20 g whey protein, 3 g total leucine, 9 g carbohydrates, 3 g fat, 800 IU vitamin D, and a mixture of vitamins, minerals, and fibers twice daily</td>
<td>7, 13 wk</td>
<td>ASM, hand grip strength, SPPB, chair stand test, gait speed, balance test, serum 25-hydroxyvitamin D, serum IGF-1</td>
</tr>
<tr>
<td>Björkman et al., 2020 [14]</td>
<td>Randomized controlled trial</td>
<td>Intervention (N=73)</td>
<td>83.6±4.7</td>
<td>51/21</td>
<td>BIA</td>
<td>20 g whey protein twice a day Given instructions on home-based exercise</td>
<td>12 mo</td>
<td>Hand grip strength, SPPB, continuous summary physical performance scores, SMI, MNA, dietary record, MMSE</td>
</tr>
<tr>
<td>Yamada et al., 2019 [15]</td>
<td>Randomized controlled trial</td>
<td>Intervention (N=28)</td>
<td>84.9±5.6</td>
<td>20/8</td>
<td>BIA</td>
<td>10.0 g of whey proteins and 800 IU vitamin D 30 minutes of body weight resistance exercise with slow movement speeds twice a week</td>
<td>12 wk</td>
<td>ASM, hand grip strength, knee extension torque, phase angle, echo intensity for rectus femoris, gait speed, one-leg standing time, chair stand time</td>
</tr>
<tr>
<td>Rondanelli et al., 2020 [16]</td>
<td>Randomized controlled trial</td>
<td>Intervention (N=28)</td>
<td>81±7.0</td>
<td>38/26</td>
<td>BIA</td>
<td>20 g of whey proteins, 2.8 g of leucine, 9 g of carbohydrates, 3 g of fat, 800 IU of vitamin D, and a mixture of vitamins, minerals (calcium 500 mg), and fibers 20–30-minute session; muscle-strengthening exercises, balance, gait exercises</td>
<td>4–8 wk</td>
<td>ASM, SMI, change in 4-m gait speed per month, hand grip strength, SPPB, chair stand test, timed up and go test, body weight, MNA, CRP, serum 25-hydroxyvitamin D, cholesterol, albumin, creatinine</td>
</tr>
</tbody>
</table>

DXA, dual-energy X-ray absorptiometry; ASM, appendicular skeletal muscle mass; SPPB, Short Physical Performance Battery; BMI, body mass index; MMSE, Mini Mental State Examination; HbA1c, whole-blood glycated hemoglobin; hS-CRP, high-sensitivity C-reactive protein; IGF-1, insulin-like growth factor 1; BIA, bioimpedance analysis; SMI, skeletal muscle mass index; MNA, Mini Nutritional Assessment.
and two-tailed p-values are provided. All extracted outcome data were calculated as the standardized mean difference (SMD) compared to the control group. Fixed-effects or random-effects models were used depending on the existence of heterogeneity. A fixed-effects model was used when the statistical heterogeneity was insignificant ($I^2$ values were $\leq 50\%$); otherwise, a random-effects model was used.

**RESULTS**

**Search results**

Fig. 1 shows a flowchart of the selection process. Of the 332 studies retrieved using the above-mentioned keywords, 139 were selected after excluding duplicate articles. After confirming the title and abstract, 106 articles were excluded. In addition, 27 studies could not be included in the meta-analysis because of irrelevant study design or insufficient data. Six studies were finally included in this review.

**Study characteristics**

The nutritional interventions and protocols used for the exercise training are summarized in Table 1. The nutritional supplementation protocols varied widely among the included trials. The majority of the included RCTs provided extra protein supplements with amounts of whey protein ranging from 10.0 to 40.0 g/day [9]. One RCT used leucine (1 g), arginine (1.5 g), and vitamin-D 300 IU complex without whey protein. Vitamin-D levels ranged from 600 to 1,600 IU/day. One study used only whey protein as a nutritional supplement without other additives [14]. Regarding the mode of exercise, one RCT used only resistance exercise training. Four RCTs used multi-component exercise regimens. One RCT did not include an exercise program before supplement intake.

**Outcomes**

In this meta-analysis, a group of patients who received whey protein or amino acid or vitamin-D supplementation was defined as the experimental group, and a group of patients who received a placebo was defined as the control group.

In the ASM analysis, of 536 patients, 263 in the experimental group received the protein supplementation, while 273 in the control group did not. There was a significant difference between the experimental and control groups with regard to ASM (SMD=0.41; 95% CI, 0.24–0.58; p<0.001; $I^2$=1%; Fig. 2).

In the analysis of handgrip strength, of 715 patients, 351 in the experimental group received the protein supplementation, while 364 in the control group did not. There was no statistically significant difference between the experimental and control groups in handgrip strength (SMD=0.37; 95% CI, -0.32–1.07; p=0.29; $I^2$=94%; Fig. 3A).

In the analysis of the SPPB scores, among 667 patients, 327 in the experimental group received the protein supplementation, while 340 in the control group did not. There was no statistically significant difference between the experimental and control groups in SPPB scores (SMD=0.35; 95% CI, -0.47–1.18; p=0.40; $I^2$=94%; Fig. 3B).

**Quality assessment**

In terms of methodological quality, all participants were randomized using established allocation sequences. Of the 42 domains among all studies, 31 domains (73.8%) were of low risk. Therefore, the overall risk of bias was determined to be low, and the studies included in this meta-analysis were assessed as of high quality (Fig. 4).

**Publication bias**

The funnel plot for the ASM was symmetrical. In contrast, the graphic funnel plots for handgrip strength and SPPB scores were asymmetrical (Fig. 5). In addition, Egger’s linear regression test indicated an insignificant publication bias for ASM (p=0.12), handgrip strength (p=0.82), as well as SPPB (p=0.69).
**DISCUSSION**

In this meta-analysis, protein supplementation significantly increased ASM in older adults with sarcopenia and tended to improve functional outcomes such as handgrip strength and SPPB scores. Sarcopenia is the progressive loss of muscle mass, strength, and function related to aging [17]. In older adults, chronic inflammation, motor neuron atrophy, reduced protein intake, and immobility can contribute to the progression of sarcopenia [18]. Furthermore, managing sarcopenia in older adults is crucial as it could lead to fatal adverse events, including increased risk for falls, impaired mobility, increased healthcare
costs, and mortality [4].

In our study, the ASM increased significantly after protein supplementation (SMD=0.41). The groups in the six studies were homogeneous, and meaningful conclusions could be drawn ($I^2$=1%). These findings are consistent with those of a previous study showing that whey protein, leucine, or vitamin-D-enriched supplementation in patients with sarcopenia increased appendicular muscle mass [19]. In contrast, one RCT reported that protein supplementation does not increase ASM in older patients with sarcopenia but improves physical performance [20]. However, this study had some limitations as it did not implement the exercise therapy with nutritional support, in addition to a smaller sample size ($n=65$) compared to that in our study.

Previous studies reporting the effect of nutritional supple-

ments on sarcopenia mainly concluded with primary outcome measures of sarcopenia indices, including lean body mass, appendicular lean mass, or skeletal mass index [21,22]. However, there were few studies with a large sample size whose outcome measures of functional performance were SPPB, gait speed, or chair-stand test [3].

Handgrip strength and performance scored with SPPB tended to improve, although this was not statistically significant (SMD=0.37; SMD=0.35). Another meta-analysis showed that changes in appendicular lean mass were significantly associated with leg strength and walking capability [23]. The heterogeneity of the participant groups included in the muscle strength and performance evaluation may have increased the variance in this study. As this study did not confirm a change in muscle mass affecting muscle strength and functional mobility, further studies are needed. Handgrip strength is a diagnostic tool for sarcopenia in the geriatric population and is known to reflect sarcopenic conditions better than other measurement tools, such as the chair-stand test [24]. Low handgrip strength could be a main predictor of mortality and adverse events in older individuals with sarcopenia [25]. In fixed-effect model, we observed a tendency for handgrip strength to improve after protein supplementation (SMD=0.29; $p<0.001$). Protein supplementation could increase muscle mass and improve physical function. This could eventually lead to reduced mortality and risk for falls and a better quality of life in older adults with sarcopenia [26]. Considering the heterogeneity, further studies with homogenous groups are needed.

The SPPB is suggested as a good alternative for gait speed to assess physical performance in sarcopenia. The SPPB consists of three tests for lower limb function, balance, strength, and mobility and is a comprehensive evaluation of functional mobility. The SPPB score predicts long-term mortality [27] and evaluates the ability to perform resistance and aerobic exercises to prevent sarcopenia. This study showed that protein supplementation would increase SPPB scores in fixed-effect model (SMD=0.32; $p<0.001$). Improvements in SPPB scores are expected to prevent frailty, hospitalization, and mortality in older adults [28].

In our analysis, studies involving the use of protein supplements and whey proteins were the primary focus. Selecting high-quality proteins as nutritional supplements could effectively increase muscle mass and functional performance. Such supplements are also easy for older adults to digest, considering the physiological and metabolic changes that occur with aging [29]. Whey protein affects muscle strengthening differently in

Fig. 4. Summary of the quality assessment of the randomized controlled trials included in the meta-analysis.
older individuals than that in young individuals. Whey protein, a rapidly digested protein, is utilized more when consumed with other carbohydrates, especially in older adults. The addition of amino acids, or specifically, leucine, is also recommended [30].

This study showed that protein supplementation increased ASM, regardless of the type, duration, and intensity of exercise. Protein supplementation and muscle-strengthening exercises contribute to increased muscle strength and walking capability [23]. Aerobic and resistance exercises reduced the time interval between muscle protein breakdown and synthesis. Therefore, a protein nutritional supplement and a concomitant aerobic or resistance exercise program can be recommended to reduce the
rate of muscle loss. In addition, early exercise and nutritional intervention could be helpful in an earlier restoration of lower extremity muscle mass for sarcopenia in older adults. Appropriate early resistance training with nutritional support and subsequent structuralized home-based exercise should be administered [31].

This study has several limitations. The heterogeneity of the intervention regimen made it difficult to conclude the effectiveness of each protocol due to the variation among protein supplement regimens (protein source, supplied amounts, and timing of ingestion) and exercise regimens (type of training, training duration, and training volume). Among the six studies we selected, the functional mobility assessment protocols were inconsistent. This resulted in the extraction of only limited valid data. However, we attempted to select the main assessment tools for sarcopenia, such as handgrip strength and SPPB. Additionally, the follow-up was limited to a short-term period (12 weeks to 1 year). Well-designed RCTs with longer follow-up periods could help establish the long-term effect of protein supplementation in older patients with sarcopenia.

In conclusion, protein supplementation significantly increases appendicular muscle mass in older patients with sarcopenia and could lead to improvements in functional outcomes, such as handgrip strength and SPPB scores. Therefore, sufficient protein supplementation may be crucial for managing sarcopenia in older individuals.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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None.

AUTHOR CONTRIBUTION

Conceptualization: Kwon HE, Koh SE. Methodology: Kwon HE, Ko N. Formal analysis: Kwon HE, Yuk D, Choi SW. Project administration: Kwon HE, Ko N. Visualization: Kwon HE, Yuk D, Choi SW. Writing – original draft: Kwon HE, Ko N. Writing – review and editing: Kwon HE, Ko N, Yuk D, Koh SE. Approval of final manuscript: all authors.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.5535/arm.23076.

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REFERENCES

Effects of Protein Supplementation in Older Adults With Sarcopenia


Korean Version of the Longer-Term Unmet Needs After Stroke Questionnaire

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Objective: To translate the 22-item Longer-term Unmet Needs after Stroke (LUNS) questionnaire, validate it in the Korean stroke population, and assess the reliability of face-to-face and telephone surveys.

Methods: Sixty-six adult patients with stroke from Seoul National University Bundang Hospital and Kangwon National University Hospital were involved in the validation. Participants were interviewed twice using the LUNS Korean version: first, a face-to-face survey for validation, and second, a telephone survey for test-retest reliability. Participants completed the Frenchay Activities Index (FAI) and Short Form 12 (SF-12) Mental and Physical Component Summary (MCS and PCS) scores at the first interview. For concurrent validity, the differences in health status (FAI, SF-12 MCS and PCS) between the groups that reported unmet needs and those that did not were analyzed for each item. Cohen’s kappa and percentage of agreement between the first and second administrations were calculated for each item to determine the test-retest reliability.

Results: The average age of the participants was 61.2±12.8 years and 74.2% were male. Fifty-seven patients were involved in the second interview. Depending on the unmet needs, SF-12 MCS, PCS, and FAI were significantly different in 12 of 22 items. In the test-retest reliability test, 12 items had a kappa of 0.6 or higher, and two had a kappa of <0.4.

Conclusion: The LUNS instrument into Korean (LUNS-K) is a reliable and valid instrument for assessing unmet health needs in patients with stroke. In addition, telephone surveys can be considered reliable.

Keywords: Stroke, Needs assessment, Factor analysis, Translations, Validation studies

INTRODUCTION

Stroke is one of the leading causes of disability worldwide, including in Korea, resulting in a significant socioeconomic burden [1,2]. Stroke mortality rates have decreased dramatically with advancements in the emergency medical system and acute care after stroke. However, the stroke incidence rates have decreased less steeply, suggesting that more stroke survivors will...
live with disabilities [1]. Although early and intensive rehabilitation after stroke is prioritized in many countries [3,4], many stroke survivors eventually experience long-term disabilities, even years after the onset of stroke [5]. A multicenter cohort study in Korea revealed that 38% of stroke survivors had at least one functional dependence, estimated using a functional independence measure 6 months after stroke [6]. During long-term follow-up after stroke in Korea, patients with stroke experience worsening problems in various domains (i.e., communication, cognition, pain, and mood), leading to lower health-related quality of life [7]. Consequently, many patients with stroke have long-term care needs. However, these needs have not been adequately met in several cases. In a recent systematic review of Longer-term Unmet Needs after Stroke (LUNS), approximately 73% of stroke survivors had at least one unmet need [8], which is associated with a low quality of life for stroke survivors or their caregivers [9-11].

Therefore, systematical identification of the current status of unmet needs in various domains using a validated tool is crucial for formulating a policy to adequately and efficiently address unmet needs. A LUNS monitoring tool consists of 22 items for various needs in multiple domains including information, service, social/emotional consequences, and health-related problems of stroke survivors, and it comprises dichotomous (yes/no) responses for each item. LUNS was developed based on previous literature and semi-structured interviews with stroke survivors [12,13]. In an original validation study among 850 British stroke survivors, LUNS showed good acceptability (average completion time of 6 minutes and low missing item rate) [12]. Test-retest reliability analysis revealed high agreement, ranging from 78%–99% for item responses, and a kappa coefficient ranging from 0.45–0.67. Additionally, the validity of the LUNS was corroborated by the identification of unmet needs that consistently correlated with poorer health, as measured by the Short Form 12 (SF-12) questionnaire and Frenchay Activities Index (FAI). However, the LUNS has not been widely translated and validated in languages other than Dutch [14]. The unmet needs of stroke survivors can be influenced by various health and social factors and different coping strategies are required depending on cultural backgrounds. Thus, using the same standardized and validated tool to evaluate unmet needs after stroke in various languages will allow for more inclusion of minority groups in multiethnic countries and enable global comparisons of unmet needs after stroke.

This study had two main objectives: the translation of the 22-item LUNS questionnaire into Korean and the evaluation of its validity among stroke patients in Korea. In addition, we analyzed the reliability between the face-to-face (first test) and telephonic (second test) surveys, to determine the reliability of follow-up telephonic surveys using the LUNS instrument. The successful implementation of this approach provides a valuable opportunity to include a larger cohort of stroke survivors in future research.

METHODS

Translation of the LUNS instrument into Korean

The translation of the LUNS instrument was conducted with permission from the authors of the original LUNS study for the use of the questionnaire. This study was structured into three distinct components. The first part involved the translation and cross-cultural adaptation of the original English version of the LUNS instrument into Korean (LUNS-K). The second part focused on the validation of the LUNS-K. Finally, we assessed the reliability between the face-to-face (first test) and the telephonic (second test) surveys. The translation and cross-cultural adaptation of the LUNS to Korean was based on the 10 steps described in the International Society for Pharmacoeconomics and Outcomes Research Patient-Reported Outcomes Translation and Linguistic Validation Task Force guidelines [15]. The Institutional Review Boards (IRBs) of Seoul National University Bundang Hospital (IRB No. B-2006-616-307) and Kangwon National University Hospital (IRB No. KNUH-2020-05-005-004) approved the study protocol. All participants provided written informed consent after receiving detailed information about the study.

The original version of the LUNS was initially translated from English to Korean. The translations were independently performed by three translators who were Korean native speakers. Two of the translators had no medical background, whereas the third translator was part of the medical team that participated in the study. The three translated versions were reviewed, and a few discrepancies were reconciled by consensus. A synthetic version was created. The reconciled Korean version was back-translated into English by two Korean-American native English speakers who were fluent in Korean (one medical personnel and one non-medical personnel), and blinded to the original English version. An expert committee comprising health professionals, translators, and linguists reviewed the synthesized and back-translated versions for inconsistencies before modifying them to reflect the most accurate meaning in Kore-
an. An expert committee reviewed the linguistic and cultural qualities of the modified version.

This pre-final version was field-tested on six Korean patients with chronic stroke (n=3 males; mean age, 65.8±23.5 years) at Seoul National University Bundang Hospital for the cognitive debriefing phase. The patients underwent qualitative semi-structured interviews investigating the questionnaire and their understanding of the questions. The interviewees were patients who visited our outpatient clinic because of chronic stroke. We measured the questionnaire completion time for four of the six patients. The semi-structured interviews were based on eight questions. All questions were answered on a visual analog scale of 100 mm where “0” represented “not useable at all” and “100” represented “very useable” [16]. After cognitive debriefing, ambiguous expressions were modified through discussion. An expert committee reviewed the final LUNS-K.

**Participants for validation and reliability tests**

The validation and reliability analysis of the LUNS-K involved a total of 66 post-stroke patients who attended the outpatient clinics of the Department of Rehabilitation Medicine at Seoul National University Bundang Hospital and Kangwon National University Hospital between July 2020 and February 2021. The study included adult stroke patients aged 18 years or older, who were outpatients and had experienced a stroke at least 6 months prior. Participants were required to have the communication and cognitive abilities necessary to independently complete the questionnaire. We included patients who reside at home and have surpassed a minimum of 3 months since stroke onset. Those unable to answer the questionnaire due to cognitive decline were excluded from the study.

During the initial face-to-face interview, participants provided information regarding their age, sex, education level, residence (home or facility), type of stroke (cerebral infarction, cerebral hemorrhage, or unknown), stroke stage (subacute, <6 months; early chronic, 6–18 months; late chronic, >18 months) [17], and modified Rankin Scale (mRS) were investigated (0=no symptoms; 1=no significant disability despite symptoms; 2=slight disability; 3=moderate disability; 4=moderately severe disability; and 5=severe disability) [18]. Two weeks after the first interview, a telephonic survey was conducted to verify the reliability of the LUNS-K for respondents who consented.

**Concurrent validity**

To evaluate the validity of the LUNS-K questionnaire, a survey was conducted using the FAI and the SF-12 to assess the quality of life. The FAI is a specific index developed to assess disability and handicap in stroke patients. It consists of 15 items that capture various activities related to the household, work or leisure, and outdoor life. Participants rated each item on a four-category scale ranging from “never” (1) to “most of the time” (4). The total FAI score ranges from 15 (lower activity) to 60 (higher activity). This index provides insight into activities that reflect a greater level of independence and social functioning. The Korean version of the FAI was translated and demonstrated satisfactory reliability, with a Cronbach’s α coefficient of 0.796 [19].

We used the Korean version of the SF-12 v2 [20], a short-form health survey with 12 items obtained directly from the SF-36 v2. The SF-12 v2 consists of the following eight scales: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. We used scales of 0–100 based on the scoring manual. Two summary measures were derived from the 12 items (Physical Component Summary [PCS] and Mental Component Summary [MCS]).

The median and interquartile range (minimum-maximum) of values on the FAI, SF-12 MCS, and SF-12 PCS were calculated for patients with and without unmet needs per item. The Mann–Whitney U-test was used to determine the statistical significance of the difference in FAI, SF-12 MCS, and SF-12 PCS scores between those with and without unmet needs.

**Reliability between the face-to-face and telephonic surveys**

To evaluate the level of agreement between the face-to-face and the telephonic surveys, Cohen’s kappa coefficient (κ), which ranges from -1 to +1, was measured. A κ-value of 0 indicates the level of agreement that would be expected by chance alone, while a value of 1 signifies a perfect agreement between the raters [21]. Additionally, the percentage agreement was calculated and ranged from 0 to 100 where 0 denotes no agreement and 100 represents perfect agreement.

**Statistical analysis**

Statistical analysis was performed using Jamovi version 1.2.27, a free open-source graphical user interface for R software, and statistical significance was set at p<0.05.

**RESULTS**

**Translation and cultural adaptation**

During the reconciliation of the forward-translated versions
into a single forward translation in the cognitive debriefing phase, six patients were requested to complete the LUNS-K and a questionnaire assessing their understanding of the questions. During the field testing of the prefinal LUNS-K version, the questionnaire completion time was <5 minutes on average. Furthermore, patients rated the length, readability, and clarity of the LUNS-K and reported that the questionnaire had a good layout and was organized in a clear manner (Table 1). Overall, 22 items were translated and validated (Supplementary Table S1).

**Participant characteristics**

In total, 66 patients with stroke participated in the initial evaluation, with 49 of those recruited from Hospital A and 17 from Hospital B. Five participants opted out of the re-evaluation process and four patients who initially agreed to the second evaluation did not respond to phone calls. Ultimately, 57 participants (86.4% of the original sample) completed the second (telephonic) survey. Table 2 shows the baseline characteristics of the 66 patients who participated in the first evaluation. Forty-nine of the 66 patients (74.2%) were male (mean age, 61.2±12.8 years). For the educational level, three patients did not respond and most responders were high school graduates (n=20, 31.7%). Most participants (98.5%) lived at home. For stroke type, ischemic, hemorrhagic, and unknown stroke types comprised 51.5%, 43.9%, and 4.5%, respectively. The proportion of participants with a period of 3–6 months, 6–18 months, and >18 months after stroke onset were 9.1%, 22.7%, and 68.2%, respectively. The disability level was assessed using the mRS, and moderate disability (mRS=3) was the most frequent disability (28.8%). The SF-12 MCS, SF-12 PCS, and FAI total scores were 41.5±13.8, 36.7±8.4, and 31.2±11.9, respectively.

**Concurrent validity**

The concurrent validity findings for the 66 participants are summarized in Table 3. Among the 21 items, individuals without unmet needs exhibited a higher level of daily activity and quality of life than those with unmet needs except one item (item #1), where individuals with unmet needs reported a higher daily activity and quality of life, although the difference was not statistically significant. Notably, significant differences were

<table>
<thead>
<tr>
<th>Table 2. Socio-demographic characteristics of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics</strong></td>
</tr>
<tr>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Sex (male)</td>
</tr>
<tr>
<td>Age (yr)</td>
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<tr>
<td>Education</td>
</tr>
<tr>
<td>Middle school or lower</td>
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<tr>
<td>High school</td>
</tr>
<tr>
<td>College or university</td>
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<tr>
<td>Graduate school</td>
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<tr>
<td>Current residence (home)</td>
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<tr>
<td>Stroke types</td>
</tr>
<tr>
<td>Ischemic</td>
</tr>
<tr>
<td>Hemorrhagic</td>
</tr>
<tr>
<td>Unknown</td>
</tr>
<tr>
<td>Stroke stage</td>
</tr>
<tr>
<td>Subacute (3–6 mo)</td>
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<tr>
<td>Early chronic (6–18 mo)</td>
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<tr>
<td>Late chronic (&gt;18 mo)</td>
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<tr>
<td>Modified Rankin Scale</td>
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<tr>
<td>0</td>
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<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>SF-12 Mental Component Summary score</td>
</tr>
<tr>
<td>SF-12 Physical Component Summary score</td>
</tr>
<tr>
<td>Frenchay Activities Index total score</td>
</tr>
</tbody>
</table>

Values are presented as number (%), mean±standard deviation, or mean±standard deviation (minimum–maximum).

<table>
<thead>
<tr>
<th>Table 1. The usability of the Longer-term Unmet Needs after Stroke instrument into Korean (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
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<td>---------</td>
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<tr>
<td>1</td>
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<td>6</td>
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<tr>
<td>7</td>
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<tr>
<td>8</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation and are rated on a visual analogue scale from 0 to 100.
<table>
<thead>
<tr>
<th>LUNS items (no. of unmet need, %)</th>
<th>LUNS items (no. of unmet need, %)</th>
<th>LUNS items (no. of unmet need, %)</th>
<th>LUNS items (no. of unmet need, %)</th>
<th>LUNS items (no. of unmet need, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information on stroke (n=53, 80.3)</td>
<td>23 (19–23.5)</td>
<td>26 (19–28.3)</td>
<td>0.074</td>
<td>32 (20–34)</td>
</tr>
<tr>
<td>2. Medication or blood check-up (n=20, 30.3)</td>
<td>31 (22.3–39.8)</td>
<td>30 (19–28.3)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>3. Pain (n=34, 51.5)</td>
<td>32 (23–38.5)</td>
<td>30 (19–26.3)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>4. Difficulties walking (n=21, 31.8)</td>
<td>32 (23–43.5)</td>
<td>25 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>5. Fear of falling (n=43, 65.2)</td>
<td>32 (25.5–44.0)</td>
<td>30 (19–38.3)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>6. Need for aids or adaptations inside (n=21, 31.8)</td>
<td>36 (26–43.5)</td>
<td>22 (17–23.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>7. Need for aids or adaptations outside (n=11, 16.7)</td>
<td>31 (20.5–40.5)</td>
<td>25 (19–28.3)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>8. Information on driving (n=23, 34.8)</td>
<td>31 (23.0–40.5)</td>
<td>26 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>9. Information on public transportation (n=20, 30.3)</td>
<td>31.5 (20.5–40.5)</td>
<td>24.5 (19–28.3)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>10. Help in the household (n=16, 24.2)</td>
<td>31 (20.3–40.5)</td>
<td>27 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>11. Information on moving to another home (n=14, 21.2)</td>
<td>30 (20.3–40.5)</td>
<td>27 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>12. Advice on the diet (n=30, 45.5)</td>
<td>32 (22.0–39.5)</td>
<td>28.5 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>13. Help with managing money (n=21, 31.8)</td>
<td>32 (20.3–40.5)</td>
<td>27 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>14. Help with personal care (n=21, 31.8)</td>
<td>33 (23–42)</td>
<td>24 (19–28.3)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>15. Information on employment (n=16, 24.2)</td>
<td>31.5 (20.5–40.5)</td>
<td>27 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>16. Help with household chores (n=11, 16.7)</td>
<td>31.5 (20.5–40.5)</td>
<td>27 (20–34.5)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>17. Help with daily occupations (n=24, 36.4)</td>
<td>36 (25.5–46.0)</td>
<td>26 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>18. Help with the physical relationship (n=6, 9.1)</td>
<td>36 (25.5–46.0)</td>
<td>26 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>19. Help with concentration or memory (n=30, 45.5)</td>
<td>36 (25.5–46.0)</td>
<td>26 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>20. Help with mood (n=34, 51.5)</td>
<td>36 (25.5–46.0)</td>
<td>26 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>21. Advice on daily occupations (n=24, 36.4)</td>
<td>36 (25.5–46.0)</td>
<td>26 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
<tr>
<td>22. Information on holidays (n=24, 36.4)</td>
<td>36 (25.5–46.0)</td>
<td>26 (19–33)</td>
<td>0.046</td>
<td>36 (20–43.5)</td>
</tr>
</tbody>
</table>

Values are presented as the median (interquartile range).

LUNS, Longer-term Unmet Needs after Stroke; FAI, Frenchay Activity Index; SF-12, Short Form 12; PCS, Physical Component Summary; MCS, Mental Component Summary.

* p<0.05, ** p<0.01 using Mann–Whitney U-test.
observed in the SF-12 MCS, SF-12 PCS, and FAI scores for 12 items.

Among the 21 items, individuals without unmet needs demonstrated significantly higher FAI scores in areas related to levels of independence and social functioning, such as the need for aids or adaptations inside, assistance with concentration or memory, support for mood, advice on daily occupations, and information on holidays. Similarly, the SF-12 PCS scores in individuals without unmet needs were significantly higher for pain, difficulties walking, need for aids or adaptations inside, need for aids or adaptations outside, help with personal care, advice on daily occupations, and information on holidays. Regarding the SF-12 MCS, individuals without unmet needs had significantly higher scores for fear of falling, information on public transportation, help in the household, help with concentration or memory, help with mood, advice on daily occupations, and information on holidays.

Reliability between the face-to-face and telephonic surveys
Table 4 shows the results of the reliability evaluation conducted using 57 patients. One item had an almost perfect agreement (κ >0.80), 11 items demonstrated substantial agreement (κ, 0.61–0.80), eight items showed moderate agreement (κ, 0.41–0.60), and two items showed fair agreement (κ, 0.21–0.40), with the percentage of agreement ranging from 73.7% (pain) to 93.0% (help with bladder or bowel problems).

Unmet needs in the study population
Common unmet needs (>50%) reported by participants during the face-to-face (T1) interview included information on stroke (80%), fear of falling (65%), help with applying for benefits (55%), pain (52%), and help with mood (52%). Less common unmet needs (<30%) during T1 interviews included advice on physical relationships (9%), help with bladder or bowel problems (15%), need for aid or adaptations outside (17%), information on moving to another home (21%), information on employment (24%), and help in the household (24%; Fig. 1).

DISCUSSION
In this study, we translated and cross-culturally adapted the LUNS questionnaire to Korean and assessed its validity and
test-retest reliability in stroke survivors. Our findings show that the LUNS-K is a reliable and valid instrument for measuring unmet needs in Korean patients with stroke. Field testing is a comprehensive and feasible method. In a larger group, field testing showed high agreement between the face-to-face and telephone tests and yielded a few missing items. For 12 of 22 items, those with unmet needs had significantly lower scores on one or more instruments for activities and quality of life, demonstrating their validity.

In terms of concurrent validity, the results of the original validation study conducted by the LoTS care LUNS study team showed that 21 items were significantly associated with lower scores on the FAI or the SF-12. In our study, however, only 12 items showed significant associations. This difference in concurrent validity findings could be attributed to several factors. First, our study had a smaller sample size, which might have lowered the statistical power and limited the ability to detect significant associations. Second, the higher percentage of unmet needs per item in our study population might have contributed to the reduced number of significant associations. Lastly, the longer timeframe in our study, including stroke survivors at various stages of recovery, could have influenced the concurrent validity results compared to the original study, which focused on participants within the 3–6 months post-stroke period.

In this study, we compared the results of the first survey conducted in person with the second survey conducted via telephone. Of 22 items, 20 showed a moderate reliability or better, while two items (items #7 and #18) showed a marginally fair reliability ($\kappa=0.394$ and $0.397$, respectively). Considering that the two surveys were conducted using different methods, the reliability of the LUNS-K is believed to be acceptable for clinical usage.

The unmet need for aids or adaptation outside only showed marginal reliability between the surveys, with 16.7% of the participants providing a “yes” response to the question. Of 22 items, 20 showed a moderate reliability or better, while two items (items #7 and #18) showed a marginally fair reliability ($\kappa=0.394$ and $0.397$, respectively). Considering that the two surveys were conducted using different methods, the reliability of the LUNS-K is believed to be acceptable for clinical usage.

The unmet need for advice on physical relationships only showed marginal reliability between the surveys, with 16.7% of the participants providing a “yes” response to the question. The LUNS-K questionnaire included examples of outside adaptations such as “ramp” or “rail” as in the original LUNS. However, these modifications of the outside environment can be unfamiliar in a Korean setting, as Korean people tend to live in apartments. This lack of familiarity with outside adaptations may have made the question vague for the participants. Thus, a more detailed example or description of the item would increase the reliability of the LUNS-K.

Only 9% of the participants reported that they had an unmet need for “advice on physical relationships.” The very low rate of this unmet need may be associated with its low test-retest reliability.

---

**Fig. 1.** The percentage of stroke survivors reporting unmet needs for each item of the Longer-term Unmet Needs after Stroke instrument into Korean during face-to-face (T1, n=66) and telephonic (T2, n=57) interviews.
reliability (κ<0.4). A previous study including Korean female patients with cervical cancer reported a low response rate for obtaining sexuality-related information [23]. They reported that participants who did not respond to sexuality-related items showed significantly different characteristics from those who responded; they were more likely to be older, unmarried, less educated, unemployed, earning a lower income, and at an advanced stage of the disease. In this study, participants did not avoid responding to sex-related items. However, considering the avoidance of sexual questions among older Koreans, they might have avoided providing an accurate response by expressing no unmet needs. Therefore, we cannot rule out the possibility that they selected “no unmet need” rather than avoid answering because the first survey was conducted face-to-face. Moreover, the question regarding help with voiding/defecation difficulty, which patients may also tend to avoid had a low prevalence (15.2%) but showed substantial reliability (κ=0.709). As such, the causal relationship between low prevalence and low reliability remains unclear. Therefore, the results of sex-related needs in future surveys on unmet needs should be interpreted with caution, due to the older age of stroke survivors and the potential cultural influences affecting their responses.

Identification of unmet needs after stroke is crucial to inform health and social service provision. In addition, understanding the specific needs of stroke survivors is vital for providing patient-centered health and social care. The prevalence of unmet long-term needs is high among survivors of stroke [8]. Patients with stroke who participated in this study most frequently reported a need for information on stroke, followed by concerns about falls, pain, and depression/anger/anxiety. Our findings are corroborated by results from a study on a Dutch stroke population [14] that reported the highest unmet needs in the stroke information domain, suggesting that clinicians should assess the need and provide sufficient information to patients with chronic stroke.

The use of different survey methods is a notable characteristic of the study. We conducted the second survey via telephone, and the response rate was 86.4%. The telephone survey method reportedly has several advantages compared with the postal survey method, including a higher response rate, reduced responder selection bias, and higher retest reliability [24]. Additionally, administering questionnaires via telephone to non-responders of postal surveys resulted in higher response rates (>80%) [25]. Telephone surveys are particularly suitable for stroke patients with physical disabilities and limited mobility. Additionally, with the increasing adoption of social distancing procedures and telecommunication, as seen during the coronavirus disease 2019 pandemic, face-to-face and group meetings have significantly declined. As a result, non-face-to-face survey methods, including telephonic surveys, are now preferred over in-person surveys. Also, conducting in-person interviews requires substantial resources and is impractical for large community populations. Therefore, we anticipate that telephonic surveys will be increasingly employed in future studies.

Our study had a few limitations. First, the inclusion of participants at different stroke stages resulted in various post-stroke periods. Patients with stroke can be classified into different stages, including acute (<3 weeks), subacute (3 weeks–6 months), early chronic (6–18 months), and late chronic (>18 months) [17]. The possibility of changes in unmet needs between the two tests (initial and second surveys) in subacute post-stroke patients could not be excluded. However, the majority of our participants were in the late chronic stage (68.2%), implying that the test was performed in a stable population. Further research should investigate and analyze unmet needs based on the specific stages of chronicity in stroke patients. Second, we did not conduct a test-retest of the face-to-face survey. Instead, the second survey was conducted via telephone. The difference in survey methods may have affected the reliability assessment of the questionnaire, particularly because people tend to respond more easily to sensitive questions via telephone than face-to-face [26,27]. Nonetheless, the advantages of administering telephonic surveys were considerable; the response rate of the second survey was >80%. Moreover, assessing the LUNS-K using both face-to-face and telephone interviews confirmed the validity and reliability of this instrument, as well as its feasibility in clinical settings using different survey methods. Finally, the participants in this study comprised post-stroke patients with the cognitive ability to understand and answer the LUNS-K. This means that the prevalence and validity of the LUNS-K in patients with severe cognitive impairment remains uninvestigated. To address this issue, further studies should include patients with stroke who have severe cognitive impairments by including these patients’ caregivers as needed.

In conclusion, the LUNS-K is a reliable and valid instrument for assessing unmet health needs in Korean patients with stroke. Unmet needs and low health questionnaire values (FAI, MCS, and PCS) were confirmed for 12 items when the validity of the LUNS-K was analyzed. Although the agreement is lower in some parts of the Korean version compared to the original En-
The English version, the reliability of the LUNS-K is still acceptable. In addition, this instrument can be reliably applied telephonically as well.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION


ACKNOWLEDGEMENTS

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SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.5535/arm.23044.

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REFERENCES

11. Kim KT, Chang WK, Jung YS, Jee S, Sohn MK, Ko SH, et al. Unmet needs for rehabilitative management in common health-related problems negatively impact the quality of life of community-dwell-
Risk Factors for Suicidality in Individuals With Spinal Cord Injury: A Focus on Physical and Functional Characteristics

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Department of Rehabilitation Medicine, National Rehabilitation Center, Seoul, Korea

Objective: To demonstrate the association between the physical and functional characteristics of individuals with spinal cord injury (SCI) and suicidality, an area of research that is less understood than the association with demographic, social, and psychological characteristics.

Methods: A retrospective cross-sectional study was conducted with 259 patients with SCI admitted for rehabilitation at the National Rehabilitation Center, Seoul, between January 2019 and December 2021. Demographic, SCI-related, physical, and functional data were collected from their medical records. Suicide risk was assessed using the Mini International Neuropsychiatric Interview.

Results: The 259 participants had an average age of 49.1 years, and 75.7% were male. The analysis revealed a statistically significant negative correlation between age and suicidality. No significant differences were found for sex, education, occupation, or SCI-related factors. Lower upper extremity motor score (UEMS) was significantly associated with higher suicide risk. Regarding functional factors, the inability to perform independent rolling, come to sit, wheelchair propelling, and self-driving were associated with increased suicidality. In the multiple linear regression analysis, lower UEMS, limited shoulder joint motion, upper extremity spasticity, and dependent wheelchair propulsion were predictors of higher suicide risk.

Conclusion: This study highlights the associations among physical status, functional dependency, and suicide risk in individuals with SCI. These findings emphasize the need to address psychological aspects and physical and functional factors in the management of individuals with SCI who are at a high risk of suicide.

Keywords: Suicide, Spinal cord injuries, Risk factors, Functional dependence, Upper extremity

INTRODUCTION

Spinal cord injury (SCI) is a devastating condition that often results in significant physical, psychological, and social consequences for affected individuals, potentially leading to even more serious outcomes such as suicide [1,2]. Understanding suicidality in the SCI population is of utmost importance, as individuals with SCI reportedly have more than a three-fold higher suicide incidence than those without SCI [3,4]. It has also been observed that 34.8% of individuals with chronic SCI experience suicidal ideation, with 17.3% having attempted suicide and a maximum of 11% resulting in fatalities [5].

Several studies have been conducted to elucidate risk factors for suicidality in patients with SCI [6-11]. Various psychological components, including a history of suicide attempts, depression, impulsivity, self-esteem issues, and alcohol misuse, have been
recognized as significant contributors to suicide risk in individuals with SCI [6,8]. Social disconnection, such as unemployment, has also been associated with increased suicidality [7,12].

While many studies have focused on the direct impact of mental and social aspects on SCI suicidality, there remains a relative lack of understanding regarding connections between the suicide tendencies of the SCI population and their physical and functional characteristics [9-11,13,14]. A fundamental consideration for the SCI population is that SCI primarily results in physical and functional challenges for affected individuals [15-17], in addition to psychosocial issues. While it is recognized that physical conditions like spasticity, pain, or reduced mobility often lead to greater dependency in daily activities and a diminished quality of life and self-identity [18-21], few studies have explicitly examined the impact of these physical and functional constraints on suicide risk [10,13]. Therefore, to identify those most at risk of suicide within the SCI population, it is important to understand how physical discomfort or functional dependency in SCI relates to suicide risk.

This study aimed to explore how certain physical and functional characteristics of individuals with SCI might correlate with reported suicidality. By understanding the combined psychosocial and physical risk factors for suicide, we aim to offer comprehensive prevention measures and early interventions for the SCI population.

**METHODS**

**Participants**

In this retrospective, cross-sectional study, the medical records of inpatients with SCI admitted to the SCI unit at the National Rehabilitation Center, Seoul, Korea, between January 2019 and December 2021 were assessed. The inclusion criteria for psychological evaluation encompassed individuals who were 18 years of age or older, possessed the capability of engaging in normal communication, and demonstrated the ability to understand and complete the survey. Individuals who did not understand the survey content or did not wish to participate were excluded. All psychological evaluations were conducted after obtaining informed consent from the participants. Among the 411 inpatients during the research period, 259 who underwent psychological evaluation were identified. This study was approved by the Institutional Review Board of the National Rehabilitation Center (#NRC-2022-01-005).

**Data collection**

Data collected included demographic factors (age, sex, body mass index, educational level, and current occupation) and SCI-related factors (duration from injury onset, severity of SCI or completeness of injury, neurological level of injury [NLI], and etiology of injury) from admission medical charts. Physical characteristics (upper extremity motor score [UEMS], lower extremity motor scores, limited range of motion [LOM] of the shoulder and hip, and spasticity of the upper and lower extremities) and functional characteristics (dependency on rolling, coming to sit, wheelchair propelling, functional ambulation categories scales, and capability of self-driving) were extracted from the physical therapy evaluation reports performed at the time of admission. These variables were classified into four groups (demographic, SCI-related, physical, and functional) based on each characteristic.

**Measurement of suicidality**

The assessment of suicidality was performed within one week from the date of admission. A psychologist with more than 10 years of clinical experience evaluated participants’ suicidality using the Korean version of the Mini International Neuropsychiatric Interview (K-MINI) [22]. The K-MINI module comprises six questions: wish for death (1 point), wish for self-harm (2 points), suicidal thoughts (6 points), suicide plans (10 points), suicide attempts in the past month (10 points), and lifetime suicide attempts (4 points) [23]. The total K-MINI score was calculated from the sum of the six questions, and the severity of suicidality was determined. Those with a score of 5 or below indicated a low suicide risk group and those with a score of 6 or above indicated a high suicide risk group. Psychological counseling has been recommended for individuals in the high suicide risk group.

**Statistical analysis**

All the statistical analysis were performed using IBM SPSS Statistics 27.0 (IBM Corp.). Participant characteristics were presented as mean±standard deviation for continuous variables, and numerical values (n) and percentages (%) for categorical variables. The association between the variables (demographic, SCI-related, physical, and functional characteristics) and suicide risk was evaluated using an independent t-test for categorical data and a Pearson correlation test for numerical data. To examine the risk factors for suicidality, simple and multiple linear regression analysis were performed using K-MINI suicide
scores as the dependent variable. Beta (β) was used to represent the change in the dependent variable for each unit change in the independent variable. Statistical significance was set at p<0.05.

RESULTS

Table 1 shows the demographic and clinical characteristics of participants. The average age of the 259 participants was 49.1±16.5 years, and 196 were male (75.7%). Of the total sample, 150 (63.8%) were unemployed. Regarding SCI-related factors, the average duration since injury was 716.7±1,867.8 days. According to the American Spinal Injury Association classification [24], incomplete injuries were more prevalent (68.1%). Tetraplegia and paraplegia accounted for 55.1% (n=140) and 44.9% (n=114) of the cases, respectively. A total of 177 (70.2%) individuals had traumatic SCI. The UEMS group obtained an average score of 35.9±15.7. Among the physical values, 35.7% (n=91) of the study participants reported LOM of the shoulder and 28.2% (n=72) had upper extremity spasticity. Suicidality, as assessed by the K-MINI module, had an average score of 1.8±3.3.

When analyzing the association between associated factors and suicide risk (Table 2), age showed a statistically significant negative correlation with suicidality (r=-0.162, p=0.021). However, no significant correlations were observed with sex, education, or occupation. Regarding SCI-related factors, no statistical significance was found in terms of the duration of injury, completeness, NLI, injury etiology, or their relationships with suicidality (p>0.05). Regarding physical characteristics, a statistically significant negative correlation was observed between UEMS and suicidality (r=-0.144, p=0.042). Compared to the low risk group, the average UEMS in the high suicide risk group was 6.5 points lower (p=0.037) (Fig. 1). Although the average total K-MINI scores were respectively 0.9 and 1.2 points higher in individuals with LOM of the shoulder (p=0.070) and upper extremity spasticity (p=0.028), no statistically significant relationships were found between the presence of all types of LOM or spasticity and increased suicidality. Among the functional characteristics, a significantly higher suicide risk was observed in cases in which participants were incapable of performing independent rolling (p=0.014), sitting (p=0.018), and wheelchair propelling (p=0.004). In particular, the average total K-MINI score of the dependent wheelchair propellers was 1.86 points higher compared to that of the independent group (p<0.001). There was also significantly higher suicidality among partici-

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value (n=259)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic factor</strong></td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>49.1±16.5</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>196 (75.7)</td>
</tr>
<tr>
<td>Female</td>
<td>63 (24.3)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.2±3.6</td>
</tr>
<tr>
<td>Education (yr)</td>
<td></td>
</tr>
<tr>
<td>&gt;12</td>
<td>110 (43.5)</td>
</tr>
<tr>
<td>≤12</td>
<td>143 (56.5)</td>
</tr>
<tr>
<td><strong>Current occupation</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>85 (36.2)</td>
</tr>
<tr>
<td>No</td>
<td>150 (63.8)</td>
</tr>
<tr>
<td><strong>SCI related factor</strong></td>
<td></td>
</tr>
<tr>
<td>Duration from injury (day)</td>
<td>716.7±1,867.8</td>
</tr>
<tr>
<td>&lt;3 mo</td>
<td>45 (17.4)</td>
</tr>
<tr>
<td>≥3 mo and &lt;6 mo</td>
<td>51 (19.7)</td>
</tr>
<tr>
<td>≥6 mo</td>
<td>163 (62.9)</td>
</tr>
<tr>
<td>Severity of SCI</td>
<td></td>
</tr>
<tr>
<td>Complete injury</td>
<td>80 (31.9)</td>
</tr>
<tr>
<td>Incomplete injury</td>
<td>171 (68.1)</td>
</tr>
<tr>
<td>Neurological level of injury</td>
<td></td>
</tr>
<tr>
<td>Tetraplegia</td>
<td>140 (55.1)</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>114 (44.9)</td>
</tr>
<tr>
<td>Etiology of injury</td>
<td></td>
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<tr>
<td>Traumatic</td>
<td>177 (70.2)</td>
</tr>
<tr>
<td>Nontraumatic</td>
<td>75 (29.8)</td>
</tr>
<tr>
<td><strong>Physical characteristic</strong></td>
<td></td>
</tr>
<tr>
<td>ASIA motor score</td>
<td></td>
</tr>
<tr>
<td>UEMS</td>
<td>35.9±15.7</td>
</tr>
<tr>
<td>LEMS</td>
<td>16.4±16.5</td>
</tr>
<tr>
<td>LOM of shoulder</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>91 (35.7)</td>
</tr>
<tr>
<td>No</td>
<td>164 (64.3)</td>
</tr>
<tr>
<td>LOM of hip</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44 (17.3)</td>
</tr>
<tr>
<td>No</td>
<td>210 (82.7)</td>
</tr>
<tr>
<td>Spasticity of upper extremity</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>72 (28.2)</td>
</tr>
<tr>
<td>No</td>
<td>183 (71.8)</td>
</tr>
<tr>
<td>Spasticity of lower extremity</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>127 (49.8)</td>
</tr>
<tr>
<td>No</td>
<td>128 (50.2)</td>
</tr>
<tr>
<td><strong>Functional characteristic</strong></td>
<td></td>
</tr>
<tr>
<td>Rolling</td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>160 (63.2)</td>
</tr>
<tr>
<td>Dependent</td>
<td>93 (36.8)</td>
</tr>
<tr>
<td>Come to sit</td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>126 (50.0)</td>
</tr>
<tr>
<td>Dependent</td>
<td>126 (50.0)</td>
</tr>
<tr>
<td>Wheelchair propelling</td>
<td></td>
</tr>
<tr>
<td>Independent</td>
<td>139 (63.8)</td>
</tr>
<tr>
<td>Dependent</td>
<td>79 (36.2)</td>
</tr>
</tbody>
</table>

(Continued to the next page)
pants unable to drive compared to those capable of self-driving (p=0.001).

In the simple linear regression analysis examining the factors influencing suicide risk, as measured by the total K-MINI scores (Table 3), the following predictors were identified as statistically significant: age (β=-0.16, p=0.021), UEMS (β=-0.14, p=0.042), spasticity of the upper extremity (β=0.16, p=0.028), dependency of rolling (β=-0.20, p=0.005), come to sit (β=-0.17, p=0.016), and wheelchair propelling (β=-0.26, p<0.001).

A multiple linear regression analysis revealed that among the physical factors, lower UEMS (β=-0.63, p=0.027), shoulder LOM (β=0.33, p=0.031), and upper extremity spasticity (β=0.47, p=0.023) were significant predictors of increased suicide risk. Among the functional characteristics, independent wheelchair propelling was a predictor of lower suicide risk (β=-0.43, p=0.018; Table 4).

**DISCUSSION**

In this study, we analyzed the association between the demographic, SCI-related, physical, and functional characteristics of participants with SCI and their suicidality based on total K-MINI scores. Results indicated that age had a statistically significant negative correlation with suicide risk. No significant associations were found with SCI-related factors, including duration from injury, completeness, and NLI. Among the physical characteristics, UEMS was significantly associated with higher suicidality scores, and lower UEMS was found to be a predictor of increased suicide risk. In terms of functional characteristics, the inability to perform independent rolling, sitting, wheelchair propelling, and self-driving was associated with higher suicid-

<table>
<thead>
<tr>
<th>Table 1. Continued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
</tr>
<tr>
<td>FAC scale</td>
</tr>
<tr>
<td>Self-driving</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation or number (%). SCI, spinal cord injury; AISA, American Spinal Injury Association; UEMS, upper extremity motor score; LEMS, lower extremity motor score; LOM, limited range of motion; FAC, functional ambulation categories; K-MINI, Korean version of the Mini International Neuropsychiatric Interview. *Analysis was conducted on the participants from whom data was available.

| Table 2. Association between suicide risk and characteristics of SCI participants |
|-------------------|-----------------|---|---|
| Characteristic     | Mean±SD         | r  | p-value |
| Demographic factor |                 |    |        |
| Age (yr)           | -0.162          | -0.021* |       |
| Sex                |                 |    |        |
| Male               | 1.6±3.2         | 0.187   |       |
| Female             | 2.3±3.7         | 0.996   |       |
| Body mass index (kg/m²) |       | 0.000   |       |
| Education (yr)     |                 |    |        |
| >12                | 1.4±3.0         | 0.234   |       |
| ≤12                | 2.0±3.5         | 0.427   |       |
| Current occupation |                 |    |        |
| Yes                | 1.6±3.4         | 0.483   |       |
| No                 | 2.0±3.5         | 0.10     |       |
| SCI related factor |                 |    |        |
| Duration from injury (day) | 0.036 | 0.615   |       |
| Severity of SCI    |                 |    |        |
| Complete injury    | 1.7±3.3         | 0.817   |       |
| Incomplete injury  | 1.9±3.4         | 0.271   |       |
| Neurological level of injury |     |        |        |
| Tetraplegia        | 2.0±3.9         | 0.458   |       |
| Paraplegia         | 1.5±2.6         | 0.293   |       |
| Etiology of injury |                 |    |        |
| Traumatic          | 1.7±3.4         | 0.483   |       |
| Nontraumatic       | 2.1±3.2         | 0.097†  |       |
| Physical characteristic |           |    |        |
| ASIA motor score   |                 |    |        |
| UEMS               | -0.144          | 0.042*  |       |
| LEMS               | -0.083          | 0.246   |       |
| LOM of shoulder    |                 |    |        |
| Yes                | 2.4±3.9         | 0.097†  |       |
| No                 | 1.5±3.0         |         |       |
| LOM of hip         |                 |    |        |
| Yes                | 2.0±3.0         | 0.458   |       |
| No                 | 1.6±3.1         | 0.458   |       |
| Spasticity of upper extremity |     |        |        |
| Yes                | 2.7±4.6         | 0.089†  |       |
| No                 | 1.5±2.8         |         |       |
| Spasticity of lower extremity |     |        |        |
| Yes                | 2.1±3.9         | 0.293   |       |
| No                 | 1.5±2.7         | 0.293   |       |
| Functional characteristic |      |    |        |
| Rolling            |                 |    |        |
| Independent        | 1.3±2.7         | 0.014*  |       |
| Dependent          | 2.7±4.2         |         |       |
| Come to sit        |                 |    |        |
| Independent        | 1.2±2.5         | 0.018*  |       |
| Dependent          | 2.4±4.0         |         |       |
| Wheelchair propelling |            |    |        |
| Independent        | 1.2±2.4         | 0.004** |       |
| Dependent          | 3.1±4.5         |         |       |
| FAC scale          |                 |    |        |
| Yes                | 0.7±1.5         | 0.001** |       |
| No                 | 2.1±3.6         |         |       |

SCI, spinal cord injury; SD, standard deviation; AISA, American Spinal Injury Association; UEMS, upper extremity motor score; LEMS, lower extremity motor score; LOM, limited range of motion; FAC, functional ambulation categories. ***p<0.001, **p<0.01, *p<0.05, and †p<0.10.
Fig. 1. Comparison of Korean version of the Mini International Neuropsychiatric Interview (K-MINI) scores with physical and functional characteristics of spinal cord injury participants. UEMS, upper extremity motor score; Low risk of suicide, K-MINI score <5; High risk of suicide, K-MINI score >6; LOM, limited range of motion; Ind, independent; Dep, dependent.

Table 3. Simple linear regression for suicide risk in spinal cord injury participants

<table>
<thead>
<tr>
<th>Factor</th>
<th>Characteristic</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic factor</td>
<td>Age (yr)</td>
<td>-0.03</td>
<td>0.01</td>
<td>-0.16</td>
<td>-2.32</td>
<td>0.021*</td>
</tr>
<tr>
<td>Physical characteristic</td>
<td>UEMS</td>
<td>-0.03</td>
<td>0.02</td>
<td>-0.14</td>
<td>-2.04</td>
<td>0.042*</td>
</tr>
<tr>
<td></td>
<td>LOM of shoulder</td>
<td>0.91</td>
<td>0.50</td>
<td>0.13</td>
<td>1.82</td>
<td>0.070†</td>
</tr>
<tr>
<td></td>
<td>Spasticity of upper extremity</td>
<td>1.20</td>
<td>0.54</td>
<td>0.16</td>
<td>2.21</td>
<td>0.028*</td>
</tr>
<tr>
<td>Functional characteristic</td>
<td>Rolling</td>
<td>-1.42</td>
<td>0.50</td>
<td>-0.20</td>
<td>-2.87</td>
<td>0.005**</td>
</tr>
<tr>
<td></td>
<td>Come to sit</td>
<td>-1.14</td>
<td>0.47</td>
<td>-0.17</td>
<td>-2.42</td>
<td>0.016*</td>
</tr>
<tr>
<td></td>
<td>Wheelchair propelling</td>
<td>-1.87</td>
<td>0.52</td>
<td>-0.26</td>
<td>-3.56</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td></td>
<td>FAC scale</td>
<td>-0.41</td>
<td>0.23</td>
<td>-0.17</td>
<td>-1.74</td>
<td>0.084†</td>
</tr>
<tr>
<td></td>
<td>Self-driving</td>
<td>-1.41</td>
<td>0.75</td>
<td>-0.14</td>
<td>-1.90</td>
<td>0.059†</td>
</tr>
</tbody>
</table>

Reference group: come to sit (0=dependent); LOM of shoulder (0=no); rolling (0=dependent); self-driving (0=no); spasticity of upper extremity (0=no); wheelchair propelling (0=dependent).

SE, standard error; UEMS, upper extremity motor score; LOM, limited range of motion; FAC, functional ambulation categories.

Table 4. Multiple linear regression for suicide risk in spinal cord injury participants

<table>
<thead>
<tr>
<th>Factor</th>
<th>Characteristic</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td>-3.24</td>
<td>3.60</td>
<td>-0.90</td>
<td>0.372</td>
<td></td>
</tr>
<tr>
<td>Demographic factor</td>
<td>Age (yr)</td>
<td>-0.04</td>
<td>0.02</td>
<td>-0.20</td>
<td>-1.64</td>
<td>0.106</td>
</tr>
<tr>
<td>Physical characteristic</td>
<td>UEMS</td>
<td>-0.20</td>
<td>0.09</td>
<td>-0.63</td>
<td>-2.27</td>
<td>0.027*</td>
</tr>
<tr>
<td></td>
<td>LOM of shoulder</td>
<td>2.26</td>
<td>1.02</td>
<td>0.33</td>
<td>2.21</td>
<td>0.031*</td>
</tr>
<tr>
<td></td>
<td>Spasticity of upper extremity</td>
<td>3.33</td>
<td>1.42</td>
<td>0.47</td>
<td>2.34</td>
<td>0.023*</td>
</tr>
<tr>
<td>Functional characteristic</td>
<td>Rolling</td>
<td>-0.62</td>
<td>1.28</td>
<td>-0.08</td>
<td>-0.48</td>
<td>0.632</td>
</tr>
<tr>
<td></td>
<td>Come to sit</td>
<td>0.29</td>
<td>1.17</td>
<td>0.04</td>
<td>0.24</td>
<td>0.808</td>
</tr>
<tr>
<td></td>
<td>Wheelchair propelling</td>
<td>-3.09</td>
<td>1.27</td>
<td>-0.43</td>
<td>-2.44</td>
<td>0.018**</td>
</tr>
<tr>
<td></td>
<td>FAC scale</td>
<td>-0.18</td>
<td>0.30</td>
<td>-0.08</td>
<td>-0.60</td>
<td>0.549</td>
</tr>
<tr>
<td></td>
<td>Self-driving</td>
<td>-0.95</td>
<td>0.96</td>
<td>-0.12</td>
<td>-0.99</td>
<td>0.327</td>
</tr>
</tbody>
</table>

Reference group: come to sit (0=dependent); LOM of shoulder (0=no); rolling (0=dependent); self-driving (0=no); spasticity of upper extremity (0=no); wheelchair propelling (0=dependent).

F (9, 60)=2.71 (p<0.01), R²=0.289.

SE, standard error; UEMS, upper extremity motor score; LOM, limited range of motion; FAC, functional ambulation categories.

***p<0.001, **p<0.01, *p<0.05, and †p<0.10.
ality. Specifically, independent wheelchair propulsion was a predictor of lower suicide risk. The analysis also indicated that LOM of the shoulder and upper extremity spasticity were predictors of higher suicide risk.

Overall, the most notable study findings pertain to the physical and functional characteristics of suicidality. With regard to physical characteristics, a lower UEMS score was found to be a predictor of increased suicide risk. Considering that UEMS is an indicator of functional dependency in SCI [25] and that muscle strength plays a key role in independent self-care in individuals with SCI [26], study participants with lower UEMS scores were presumed to have struggled to pursue functional day-to-day lives. These dependencies could lead to diminished self-efficacy and desire for life [16,27,28]. Moreover, in the current study, LOM of the shoulder and upper extremity spasticity were identified as predictors of higher suicide risk. Together with the lack of muscle strength, these physical discomforts could have concurrently contributed to the participants' mental health deterioration by causing a range of functional disturbances [15,29-31]. Physical discomfort in the lower extremities was not of particular significance. A pilot study revealed that joint contractures, particularly in the upper extremities, can negatively affect functional abilities in individuals with SCI [29]. Similar to the associations observed with physical characteristics, our results on functional characteristics provided significant insights, especially with wheelchair propulsion, a functional movement performed using the upper extremities [15]. Overall, our findings underscored the need for appropriate interventional strategies for patients with SCI with physical and functional concerns, particularly in the upper extremities.

Interestingly, among the SCI-related factors, NLI and completeness did not demonstrate any significant associations with suicidality. Previously, some studies focused on the relationship between actual death by suicide and SCI-related characteristics. Prior investigations have reported the highest standardized mortality ratio in patients with complete paraplegic SCI [4,32] and recommended caution to prevent suicide in individuals with SCI and complete injury [10]. Other reports have presented a nearly two-fold higher suicide mortality rate in paraplegic SCI than in tetraplegic SCI [7,11]. However, as these earlier findings are refined to the actual mortality of suicide, further investigation is warranted to determine the tangible impact of completeness or the level of injury on overall suicidality in the SCI population.

A meaningful correlation among demographic factors was observed between age and suicidality. This result aligns with the outcomes of previous studies that demonstrated the vulnerability of the younger population with SCI to suicide [10,33]. Before injury, young individuals often maintain a higher level of physical activity and social interaction than older adults, which may lead to a relatively greater sense of impairment and discouragement [12,34]. However, in this study, occupation did not show any statistically significant correlations with suicidality. This result was inconsistent with findings from the general population [35]. It is important to note that the study participants reported their current employment status while they were hospitalized or on leave. As a significant number of SCI populations struggle against the uncertainties of returning to their prior occupations [36,37], reliable analysis should be conducted within social backgrounds.

The present study had several limitations. Owing to the retrospective cross-sectional study design, the establishment of a cause-and-effect relationship was challenging. Additionally, the single-center recruitment of participants and sole inclusion of inpatients with SCI jointly restrict the generalizability of the findings. Our study also lacked information about the participants' specific occupations, economic status, and information regarding their caregivers, whether paid or family. Lastly, as the analysis of suicidality was based on the total K-MINI score to reflect overall suicidal tendencies, the results should be applied with caution when it comes to capturing the nuances of individual elements such as suicidal thoughts, suicide plans, and suicide attempts.

Understanding physical and functional suicide risk factors in populations with SCI is essential for several reasons. It provides support for identifying high risk individuals for targeted interventions and informs the development of tailored rehabilitation programs. Our study demonstrated that physical factors of the upper extremities and certain functional dependencies in daily activities are associated with suicidality in individuals with SCI. Considering this, our findings can contribute to the advancement of early intervention strategies for suicide prevention in individuals with SCI. This can be achieved by highlighting the necessity for structured physical and functional rehabilitation programs that incorporate upper extremity training and wheelchair activities.

**CONFLICTS OF INTEREST**

No potential conflict of interest relevant to this article was reported.
FUNDING INFORMATION

This study was supported by a grant (code#22-C-04) from the Rehabilitation Research & Development Support Program of the Korea National Rehabilitation Center, Ministry of Health and Welfare, Korea.

AUTHOR CONTRIBUTION

Conceptualization: Kim O. Methodology: Han S, Kim W, Kim O. Formal analysis: Han S, Kim W. Funding acquisition: Kim O. Project administration: Han S, Kim W, Kim O. Visualization: Han S, Kim W. Writing – original draft: Han S, Kim O. Writing – review and editing: Han S, Kim W, Kim O. Approval of final manuscript: all authors.

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REFERENCES

22. Sheehan DV, Lecrubier Y, Sheehan KH, Amorim P, Janavs J, Weller E,


INTRODUCTION

The incidence of spinal cord injury (SCI) and concomitant traumatic brain injury (TBI) varies from 25% to more than 60%, depending on the criteria used [1]. Physical, cognitive, and emotional impairments caused by TBI impede patient rehabilitation [2]. Prompt diagnosis of concomitant TBI in patients with SCI is vital for appropriate rehabilitation to manage TBI-related medical complications and maximize functional recovery [3,4]. In addition to having TBI affect the patient’s prognosis, problems
such as consciousness, cognitive deficits, and agitation impact the initial neurological examination of patients with SCI. Accompanied by mechanical ventilators, sedation, and psychiatric illness also affect the initial neurological examination of patients with SCI [5]. Among them, TBI is more concerned with being underdiagnosed than other factors. The initial imaging evaluation of the brain might be normal; however, accompanying head trauma should always be considered when there are symptoms of loss of consciousness or cognitive impairment [6,7]. This study aimed to summarize the epidemiology of patients with SCI and concomitant TBI at a regional level I trauma center and suggest considerations for the initial evaluation.

METHODS

Ethical approval
This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Pusan National University Hospital (IRB No. 2302-013-124). The informed consent requirement was waived due to the study's retrospective nature.

Study design, data collection, and definitions
This retrospective observational study was conducted at Pusan National University Hospital, Regional Trauma Center. All records of individuals diagnosed with traumatic-spinal cord injury (T-SCI) between 2016 and 2020 were reviewed. In total, 627 patients with confirmed T-SCI were hospitalized. A retrospective study was conducted on 363 individuals, excluding those with insufficient SCI documentation, such as the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), nontraumatic etiology, or old SCI. Patients who underwent at least two ISNCSCI evaluations were included in this study (Fig. 1). The institutional ethics review board approved this study.

The TBI diagnostic criteria by the American Congress of Rehabilitation Medicine applied [8]. Based on the degree of loss of consciousness posttraumatic amnesia (PTA), imaging findings, and neuropsychological findings [7,9-12], the TBI severity was classified as mild, moderate, or severe. The highest rating of severity received was used to define each patient’s TBI severity.

Typical areas of cognitive decline in people with TBI involve visuospatial, delayed recall, attention, and language [13]. The Montreal Cognitive Assessment (MoCA) is an excellent tool for evaluating this. The average MoCA score was 19, 18, and 13 points for patients with mild, moderate, and severe TBI, respectively (Table 1). Based on this, a Korean version of MoCA score of 19 or higher was considered mild TBI, 14–18 as moderate, and 13 or less as severe TBI.

The neurological examinations analyzed retrospectively in this study were performed only by skilled rehabilitation physicians who completed online training at the American Spinal Injury Association (ASIA) e-learning center; therefore, the physical examinations performed were reliable. After the accident, an

---

Table 1. Diagnostic criteria for the classification of TBI severity

<table>
<thead>
<tr>
<th>Diagnostic criteria</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altered level or loss of consciousness</td>
<td>GCS 13–15 and/or any LOC≤30 min</td>
<td>GCS 9–12 and/or 30 min≤LOC≤6 h</td>
<td>GCS 3–8 and/or LOC&gt;6 h</td>
</tr>
<tr>
<td>PTA</td>
<td>Any PTA≤24 h</td>
<td>24 h≤PTA≤7 day</td>
<td>PTA&gt;7 day</td>
</tr>
<tr>
<td>Neuroradiological findings due to TBI</td>
<td>No findings</td>
<td>Neuroradiological TBI findings</td>
<td>Neuroradiological TBI findings and neurosurgical operation</td>
</tr>
<tr>
<td>Neuropsychological findings due to TBI</td>
<td>MoCA&gt;18</td>
<td>14≤MoCA≤18</td>
<td>MoCA&lt;14</td>
</tr>
</tbody>
</table>

TBI, traumatic brain injury; GCS, Glasgow Coma Scale; LOC, loss of consciousness; PTA, posttraumatic amnesia; MoCA, Montreal Cognitive Assessment.
initial assessment was quickly conducted when cooperation was possible, and a follow-up examination was carried out before discharge.

**Statistical analysis**
Statistical analysis were performed using R version 4.2.1 (R Foundation). An independent t-test or Wilcoxon rank-sum test was conducted for continuous variables based on normality. The chi-square test or Fisher’s exact test was used for categorical variables. Statistical significance was set at a two-tailed p-value < 0.05.

**RESULTS**

**Overall incidence**
Table 2 summarizes the epidemiology of 363 patients. Sex, age, neurologic level of injury (NLI), American Spinal Injury Association Impairment Scale (AIS) score, and traumatic etiology information of 363 patients with confirmed T-SCI were classified. In addition, differences in characteristics were analyzed by categorizing only the SCI patient group and the SCI with the concomitant TBI patient group.

Among 363 patients with T-SCI, 296 (81.5%) were males, and 67 (18.5%) were females. The average age was 57.1 years. C1–4 injuries accounted for 54.8% of the patients. This was followed by affected C5–8 at 20.4%, T1–12 at 14.0%, and L1–S5 at 8.0%. AIS A, B, C, and D accounted for 25.1%, 7.7%, 26.7%, and 37.2%, respectively. T-SCI etiology was classified as fall, transport, sports and leisure, assault, and other traumatic causes [14]. Among 363 patients, fall was the most common cause (205, 56.5%), followed by transport (113, 31.1%). When calculating the p-value, the unknown initial NLI or AIS scores were regarded as missing data. Supplementary Table S1 describes the epidemiological information reviewed above by subdividing patients

**Table 2. Study characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (n=363)</th>
<th>Only SCI (n=289)</th>
<th>SCI+TBI (n=74)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>296 (81.5)</td>
<td>238 (82.4)</td>
<td>58 (78.4)</td>
<td>0.536</td>
</tr>
<tr>
<td>Female</td>
<td>67 (18.5)</td>
<td>51 (17.6)</td>
<td>16 (21.6)</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–15</td>
<td>1 (0.3)</td>
<td>0 (0)</td>
<td>1 (1.3)</td>
<td>0.329</td>
</tr>
<tr>
<td>16–30</td>
<td>28 (7.7)</td>
<td>22 (7.6)</td>
<td>6 (8.1)</td>
<td></td>
</tr>
<tr>
<td>31–45</td>
<td>45 (12.4)</td>
<td>38 (13.1)</td>
<td>7 (9.5)</td>
<td></td>
</tr>
<tr>
<td>46–60</td>
<td>114 (31.4)</td>
<td>91 (31.5)</td>
<td>23 (31.1)</td>
<td></td>
</tr>
<tr>
<td>61–75</td>
<td>133 (36.6)</td>
<td>108 (37.4)</td>
<td>25 (33.8)</td>
<td></td>
</tr>
<tr>
<td>&gt;75</td>
<td>42 (11.6)</td>
<td>30 (10.4)</td>
<td>12 (16.2)</td>
<td></td>
</tr>
<tr>
<td>Initial NLI</td>
<td></td>
<td></td>
<td></td>
<td>0.122</td>
</tr>
<tr>
<td>C1–4</td>
<td>199 (54.8)</td>
<td>167 (57.8)</td>
<td>32 (43.2)</td>
<td></td>
</tr>
<tr>
<td>C5–8</td>
<td>74 (20.4)</td>
<td>60 (20.8)</td>
<td>14 (18.9)</td>
<td></td>
</tr>
<tr>
<td>T1–12</td>
<td>51 (14.0)</td>
<td>36 (12.4)</td>
<td>15 (20.3)</td>
<td></td>
</tr>
<tr>
<td>L1–S5</td>
<td>29 (8.0)</td>
<td>26 (9.0)</td>
<td>3 (4.1)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>10 (2.8)</td>
<td>0 (0)</td>
<td>10 (13.5)</td>
<td></td>
</tr>
<tr>
<td>Initial AIS</td>
<td></td>
<td></td>
<td></td>
<td>0.009</td>
</tr>
<tr>
<td>A</td>
<td>91 (25.1)</td>
<td>66 (22.8)</td>
<td>25 (33.8)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>28 (7.7)</td>
<td>25 (8.7)</td>
<td>3 (4.0)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>97 (26.7)</td>
<td>76 (26.3)</td>
<td>21 (28.4)</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>135 (37.2)</td>
<td>120 (41.5)</td>
<td>15 (20.3)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>12 (3.3)</td>
<td>2 (0.7)</td>
<td>10 (13.5)</td>
<td></td>
</tr>
<tr>
<td>Traumatic etiology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>205 (56.5)</td>
<td>164 (56.8)</td>
<td>41 (55.4)</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>113 (31.1)</td>
<td>81 (28.0)</td>
<td>32 (43.2)</td>
<td></td>
</tr>
<tr>
<td>Sports and leisure</td>
<td>15 (4.1)</td>
<td>15 (5.2)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Assault</td>
<td>2 (0.6)</td>
<td>2 (0.7)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>28 (7.7)</td>
<td>27 (9.3)</td>
<td>1 (1.4)</td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as number (%).
SCI, spinal cord injury; TBI, traumatic brain injury; NLI, neurologic level of injury; AIS, American Spinal Injury Association Impairment Scale.
with SCI and concomitant TBI according to the TBI severity criteria.

**AIS conversion rate**

Table 3 shows the changes in the AIS changes in patients with SCI only and those in SCI patients with concomitant TBI (SCI+TBI). AIS conversion was examined by classifying the SCI-only patient groups and SCI+TBI. In addition, the subgroups were divided according to the TBI severity. In total, 318 patients had ISNCSCI follow-up records. The initial evaluation was performed 11 days (average) after the injury, and a follow-up was performed 43 days after.

In this study, ISNCSCI was performed in some patients, even in those with severe TBI. Since the initial evaluation of the injury determined TBI severity, the Glasgow Coma Scale (GCS) score was 3–8 during the trauma emergency room admission; however, the level of consciousness recovered subsequently, and ISNCSCI could be performed.

Fourteen of the 24 patients diagnosed with SCI+TBI and identified as AIS A in the initial evaluation showed neurologic recovery compared with AIS B or higher (Table 3). In contrast, in those with T-SCI without head injury, neurological recovery was confirmed in only 16 of 62 patients initially evaluated as AIS A (Fig. 2). In only patients with SCI, the conversion rate was 0.258 (95% confidence interval [CI], 0.149–0.367), whereas, in SCI+TBI, it was 0.583 (95% CI, 0.386–0.781). The conversion rate was statistically significant (p=0.010) between the SCI and the SCI+TBI groups.

Supplementary Table S2 summarizes the sex, age, TBI severity, NLI, and AIS conversion of patients with SCI+TBI whose AIS conversion was confirmed from initial AIS A to AIS B or higher.

**DISCUSSION**

This study investigated the epidemiology of patients with SCI alone and those with SCI+TBI. In Korea, regional trauma centers were opened in 2014, and 16 centers are currently opera-

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**Table 3. Change of AIS**

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (n=318)</th>
<th>Only SCI (n=256)</th>
<th>SCI+TBI (n=62)</th>
<th>Concomitant TBI severity</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mild (n=12)</td>
<td>Moderate (n=30)</td>
</tr>
<tr>
<td>AIS (initial)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>86 (27.1)</td>
<td>62 (24.2)</td>
<td>24 (38.7)</td>
<td>5 (41.7)</td>
<td>10 (33.3)</td>
</tr>
<tr>
<td>B</td>
<td>28 (8.8)</td>
<td>25 (9.8)</td>
<td>3 (4.8)</td>
<td>0 (0)</td>
<td>1 (3.3)</td>
</tr>
<tr>
<td>C</td>
<td>91 (28.6)</td>
<td>70 (27.3)</td>
<td>21 (33.9)</td>
<td>3 (25.0)</td>
<td>13 (43.4)</td>
</tr>
<tr>
<td>D</td>
<td>113 (35.5)</td>
<td>99 (38.7)</td>
<td>14 (22.6)</td>
<td>4 (33.3)</td>
<td>6 (20.0)</td>
</tr>
<tr>
<td>AIS (follow up)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>56 (17.6)</td>
<td>46 (18.0)</td>
<td>10 (16.1)</td>
<td>1 (8.3)</td>
<td>5 (16.7)</td>
</tr>
<tr>
<td>B</td>
<td>30 (9.4)</td>
<td>22 (8.6)</td>
<td>8 (12.9)</td>
<td>2 (16.7)</td>
<td>2 (6.7)</td>
</tr>
<tr>
<td>C</td>
<td>83 (26.1)</td>
<td>61 (23.8)</td>
<td>22 (35.5)</td>
<td>4 (33.3)</td>
<td>13 (43.3)</td>
</tr>
<tr>
<td>D</td>
<td>149 (46.9)</td>
<td>127 (49.6)</td>
<td>22 (35.5)</td>
<td>5 (41.7)</td>
<td>10 (33.3)</td>
</tr>
<tr>
<td>AIS conversion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS A → A</td>
<td>56 (65.1)</td>
<td>46 (74.2)</td>
<td>10 (41.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS A → not A</td>
<td>30 (34.9)</td>
<td>16 (25.8)</td>
<td>14 (58.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as number (%).
AIS, American Spinal Injury Association Impairment Scale; SCI, spinal cord injury; TBI, traumatic brain injury.
tional. This was a detailed retrospective analysis of T-SCI in a single institution after establishing a systematic regional trauma center in Korea. There is a lack of data worldwide, and this is the first study in Korea to investigate patients with SCI+TBI. A significant difference in the AIS conversion rate between the two groups was found.

Since there is a lack of consensus on evaluating patients with SCI+TBI, this study aimed to suggest considerations for initial evaluation, including ISNCSCI.

Sex
Among 363 patients with T-SCI, 296 (81.5%) were males, similar to the global 4:1 male-to-female ratio of T-SCI [15]. Similarly, according to spine epidemiological studies conducted in Korea, the ratio was 3.6:1 in the 2010s [16].

According to Asian studies, males were at a higher risk of T-SCI; the sex ratio ranged from 0.99:1 in Taiwan to 13.5:1 in India [17,18]. This inconsistency may be due to socioeconomic status and cultural background differences. Males are more likely to participate in trauma-related physical activities [19].

Age
The average age was 57.1 years, higher than the average age of T-SCI patients in the USA according to the 2021 National Spinal Cord Injury Statistical Center (NSCISC) annual report (42.2 years) [20]. Asian studies reported a range of 26.8–56.6 years [19]. A previous Korean study showed that the mean age at the time of injury increased from 32.4 years in the 1990s to 47.1 years in the 2010s [16].

This study’s proportion of older adults aged > reached 48.2%. The increasing proportion of older adults will cause changes in epidemiology, such as changes in traumatic etiology.

NLI
Considering this study’s initial NLI, affected C1–4 accounted for 54.8% of all patients with SCI, followed by affected C5–8 (20.4%). Cervical-level injuries accounted for 75.2% of the patients. This was followed by affected T1–12 at 14.0% and L1–S5 at 8.0%. In Korea, cervical-level injury accounted for 57.2% of all T-SCIs in the 2010s, of which NLI C4–6 accounted for the largest proportion over 30 years [16]. The proportion of cervical injuries was much higher than that in the current statistics. The higher-level cervical cord injuries above the meaning NLI C1–4 level accounted for 54.8%. This may be related to the characteristics of the regional trauma centers where patients with severe T-SCI visit.

Among the 74 patients with SCI+TBI, the affected C1–4 accounted for 43.2%, C5–8 for 18.9%, thoracic level for 20.3%, and lumbar level for 4.1%. There was no statistically significant difference in the initial NLI between the only SCI and the SCI+TBI groups. Macciocchi et al. [10] reported that the TBI co-occurrence rate is 70%–77% when the NLI is C1–4, 59%–67% for C5–8, and 11%–59% for levels below T1; therefore, higher-level cervical cord injury was shown to be common in patients with T-SCI and concomitant TBI [21]. Contrary to previous studies, the cervical-level injury rate in patients with SCI+TBI in this study was lower than that in patients with SCI alone. This may be due to the high severity of the patient group with cervical SCI +TBI who visited the regional trauma center. There may have been selection bias since ISNCSCI could not be performed for reasons such as death, critically ill medical condition, and persistent unconsciousness. In addition, the possibility of a certain number of undiagnosed TBIs due to another urgent trauma issue is considered cautiously.

AIS
When divided based on this study’s initial AIS, AIS A, B, C, and D accounted for 25.1%, 7.7%, 26.7%, and 37.2%, respectively. In existing USA statistics, AIS A, B, C, and D account for 41.9%, 10.7%, 12.4%, and 29.4% of the cases, respectively [20]. It is characteristic that the ratio of AIS A is minute, and that of AIS C is larger than previously known values. According to the 2021 NSCISC annual report, gunshot wounds account for 15.3% of all SCI etiologies, and there are few other penetrating injuries, such as stab wounds, in other countries [20,22,23]. However, in Korea, most injuries involve blunt trauma since penetrating injuries are infrequent and personal gun possession is prohibited under Korean law. Hence, it was estimated that the rate of AIS A was lower than that reported in previous studies in other Western countries or registry collection results.

In addition, one of the primary etiologies of SCI is transport, and Korea’s highest seat belt-wearing rate may have contributed to this [23].

The rate of AIS A was relatively high in patients with double injuries. AIS A accounted for 22.8% of patients with SCI alone and 33.8% with double injuries. Hagen et al. [6] reported that completeness of T-SCI was strongly associated with clinical TBI. The complete injury rate among 179 individuals with SCI without TBI was only 34.6%. However, the complete injury rate reached 78.9% in individuals with SCI+severe TBI. The completeness of the T-SCI indicates high-energy trauma with an in-
increased risk of concomitant TBI. This study was also consistent with previous studies.

**Traumatic etiology**

Globally, transport is the most common cause of SCI, followed by falls [15]. In a Korean study, transport-based SCI decreased from 65% of all injuries in 1990–1999 to 41.9% in 2010–2019, while fall-based SCI increased from 24.9% in 1990–1999 to 46.3% in 2010–2019 [16]. Falls were the most common cause of injury in the >60 age group, resulting in 59.1% T-SCI in the 2010s [16].

In this study, among 363 patients, fall was the most common cause (205, 56.5%), followed by transport (113, 31.1%). This is presumed to be related to the high proportion of older adults, and many cases have occurred due to slipping [24]. Older adults are vulnerable to falls due to deterioration of physical functions, including balance function, musculoskeletal system, visual perception, and cognitive function problems [25]. Besides, degeneration of various components of the vertebra is common in the elderly population. Spinal degenerative changes such as ossification of the posterior longitudinal ligament, disc disease, stenosis, and spondylolisthesis cause a higher risk of suffering SCI following a fall or another traumatic event in older adults [26]. Also, attempts to socially reduce traffic accidents, such as wearing seat belts and regulating the speed limit, could explain this change in etiology [27,28]. Other traumatic causes identified in this study included falling objects and industrial accidents, which accounted for 7.7% of the total, with 28 cases.

Among the 113 patients with transport in this study, 32 (28.3%) had TBI. Among the 205 patients with falls, 41 (20.0%) had TBI. There was no significant difference in TBI comorbidities between the two major etiology groups.

**AIS conversion**

Most importantly, as shown in Table 3, the initial AIS was A in patients with only SCI; however, the conversion rate to AIS B, C, or D in the follow-up examination was 25.8%. In contrast, in patients with SCI+TBI, AIS conversion was 58.3% (p-value 0.010). In a previous study, 20%–30% of individuals with AIS A SCI at baseline examination (within 30 days of injury) converted to an incomplete status [29-31]. However, existing studies regarding AIS conversion do not accurately identify whether TBI accompanies SCI. Besides, neurological conversion is rare after complete paraplegia (~15%–20%) relative to tetraplegia [29]. The higher neurological conversion in patients with tetraplegia than in those with paraplegia in a previous study is thought to be partly influenced by differences in the TBI frequency.

This was a single-center evaluation; however, the AIS conversion rate in SCI patients with TBI was significantly higher than that in patients with SCI alone. The patient might have been initially evaluated as AIS A due to decreased cognition and cooperation, resulting in high AIS conversion.

**Supplementary Table S2** shows the patients who had AIS A at the initial evaluation but deviated from AIS A at the follow-up evaluation. Even if not accompanied by moderate or severe TBI, four patients with SCI concomitant with mild TBI were converted to AIS B or C. The two persons who were accompanied by mild TBI but converted from AIS A to C were intubated during evaluation or lightly sedated with a score of -1 on the Richmond Agitation-Sedation Scale (RASS).

In the intensive care unit, the degree of sedation and agitation was objectively indicated using the RASS [32]. The RASS score was classified from -5 to +5 points, and patients with a score between -1 and +1 points were considered eligible for reliable physical examination in this study. Since complete injury judgment is crucial in the initial evaluation, it was possible to identify deep anal pressure and voluntary anal contraction between RASS -1 and +1. In addition to accompanying TBI, other factors that may affect physical examination findings, such as endotracheal intubation, sedation, and delirium, should be closely considered. The initial AIS assessment could be incorrect owing to the influence of concomitant TBI lesions or decreased consciousness/cognitive state due to the factors mentioned above.

There are no clear standards for the arousal, awareness, or cooperation required to implement ISNCSCI. Even if ISNCSCI evaluation is possible, it is desirable to record the GCS score during evaluation and include cognitive evaluation results such as the mini-mental state examination (MMSE), MoCA, RASS score, and Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) indicating arousal, awareness, and cooperation (Supplementary Table S3). Moreover, interpreting ISNCSCI will be easier if the examiner records the presence of severe pain that may limit the physical examination, endotracheal intubation status, and level of cognitive decline due to the underlying disease.

ISNCSCI is known to show discrepancies among experienced examiners [33]. The evaluation and scoring are challenging. In the SCI+TBI group, there were many restrictions on the implementation of reliable ISNCSCI due to the reasons discussed above. Therefore, commenting regarding consciousness and
cognition during evaluation is crucial. Furthermore, patients with an initial decline in consciousness and cognition need close follow-up since the possibility of neurological alterations in ISNCSCI may be high. Regarding the minimum requirements to properly perform ISNCSCI evaluation, further prospective studies are required on the arousal, awareness, and cooperation criteria.

In this study, serial cognitive function tests were rarely performed in patients with AIS conversion. There are limitations to performing serial cognitive function tests during the acute treatment period in patients with trauma. A series of cognitive evaluation tests are recommended in patients initially evaluated as having AIS A but whose neurologic recovery was beyond AIS B in the follow-up evaluation. Suppose AIS conversion is confirmed along with cognitive improvement in a series of evaluations. In that case, it can be inferred that the inaccurate ISNCSCI assessment is due to cognitive decline in the early phase of the injury.

The study has certain limitations. Since it was a retrospective study, the timing of initial and follow-up evaluations was inconsistent. The small sample size was not representative of the characteristics of Korea. The data were limited to a single university hospital. Considering the selection bias of a single institution, building a registry that includes the evaluation items that were limited in this study is necessary.

In conclusion, the study presents the epidemiology of SCI with concomitant TBI, lacking in research worldwide, and is the first study in Korea. Identifying the coexistence of TBI through the current national SCI registry is challenging. Hence, this is a relevant study. Establishing a global SCI patient registry and checking the medical records necessary for evaluation and follow-up is needed. In particular, when ISNCSCI is accompanied by TBI, a specific global consensus on the evaluation must be reached through further studies. The key issue is when a reliable physical examination can be performed.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION


SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.5535/arm.23054.

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REFERENCES

Traumatic Spinal Cord Injury With Concomitant Brain Injury


Effect of Adding Physiotherapy Program to the Conservative Medical Therapy on Quality of Life and Pain in Chronic Rhinosinusitis Patients

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Objective: To assess the effectiveness of combining physiotherapy techniques with conservative medical treatment in chronic rhinosinusitis (CRS) patients.

Methods: Sixty-eight volunteers with CRS were randomly assigned. Group A received only traditional medical treatment, whereas group B received a physiotherapy program that included pulsed ultrasound therapy, sinus manual drainage techniques, and self-sinus massage technique in addition to traditional medical treatment. Interventions were applied 3 sessions a week for 4 weeks. The rhinosinusitis disability index (RSDI) served as the main outcome indicator for assessing the quality of life, and the secondary outcome measure was the pressure pain threshold (PPT) using a pressure algometer.

Results: Wilcoxon signed rank test revealed a significant reduction (p<0.001) in total RSDI values from 71.08±1.13 pretest to 47.14±1.15 posttest for group A, while it decreased from 70.64±1.20 pretreatment to 31.76±1.04 posttreatment for group B; furthermore, Mann–Whitney U-test revealed a significant difference (p<0.001) in total RSDI values between both groups when comparing the change of the pre-post data values, it was 23.94±0.95 for group A and 38.88±0.67 for group B. The independent t-test revealed a highly statistically significant increase (p<0.001) in the PPT values in the experimental group compared to the control group.

Conclusion: The physiotherapy program which included pulsed ultrasound therapy, sinus manual drainage technique, and self-sinus massage technique in conjunction with conventional medical treatment was more beneficial for enhancing the quality of life and PPT than traditional medical treatment alone in CRS patients.

Keywords: Sinusitis, Quality of life, Pain threshold, Ultrasound therapy, Manual therapy
INTRODUCTION

A clinical illness known as chronic rhinosinusitis (CRS) is considered a persistent inflammation of the mucous membranes that line the paranasal sinuses and nasal cavity brought on by an infection, trauma, or exposure to irritants or allergens. Each year, 30 to 40 million people are impacted. According to estimates, 10% of Western populations are affected by CRS [1].

Nasal blockage, runny nose, facial pain, or, a smell abnormality must all be present for more than 12 weeks to be considered part of the condition. Because the symptoms are similar to those of other disorders, nasal endoscopy or diagnostic imaging must be used to confirm the presence of mucosal inflammation [2,3]. CRS is a prevalent clinical illness seen on a daily basis in otorhinolaryngology practice, and it significantly affects patients' quality of life (QoL) and ability to work, which results in a loss of productivity and leisure time. The illness costs the United States government more than 11 billion dollars every year [4,5].

Analgesia, topical decongestants, intranasal corticosteroids, oral antibiotics, and antihistamine drugs are among the treatment options for rhinosinusitis, while for serious and repetitive rhinosinusitis, operative procedures may be indicated [6,7]. Medical intervention for CRS is complicated and requires long-term antibiotic medication. Aside from the problems of long-term pharmacological treatment, persisting promotion and the emergence of drug-resistant bacterial populations prompted researchers to look into alternative therapies [8,9].

In recent years, therapeutic ultrasound (US) has been recommended as a potential treatment option for CRS individuals. The US treatment can be applied either continuously or pulsed. Although the US has an anti-inflammatory impact and can improve antibiotic treatment efficacy in CRS patients [10-13], most trials are small, short in duration, and poorly designed, and there is insufficient data to recommend US usage in clinical practice with a significant risk of bias. As a consequence, the US cannot be designated as a potential supplementary resource to current CRS treatment approaches. As a result, more clinical trials with a bigger sample size are required to demonstrate the efficacy of the US on CRS [14].

Other physical therapy modalities, such as manual therapy [15-17], laser therapy [18], and short-wave therapy [19], have been documented in the literature as a successful adjunct therapy in the treatment of CRS. As a result, the authors hypothesized that combining US therapy and manual therapy with traditional medical treatment improves the QoL and pressure pain threshold (PPT) in patients with CRS more than traditional medical treatment alone. Therefore, this study's goal was to determine how adding a combined physiotherapy program to traditional medical therapy affected CRS patients' PPT and QoL.

METHODS

This study was a prospective randomized controlled trial with a pretest/posttest, single-blind (assessor) design. The participants were recruited from outpatient clinics at Al-Qurayyat General Hospital in Al-Jouf region, Kingdom of Saudi Arabia, from September 2022 to March 2023. The current study was approved by the Research Ethics Committee, Qurayyat Health Affairs (IRB Approval No. 2022-38) and it was recorded prospectively in the Clinical Trial Registry (NCT05442606). All participants in this study gave informed consent and agreed that their data would be kept confidential and used anonymously in the analysis for the sole purpose of the study. Participants were made aware of the study's objectives and benefits, and they were free to leave at any time. The Consolidated Standards of Reporting Trials (CONSORT 2010) checklist was followed when reporting this study (available at https://www.equator-network.org/).

Participants

This study enrolled sixty-eight participants who suffering from CRS that have been clinically identified by an ear, nose, and throat (ENT) professional with the following criteria.

Inclusion criteria

Participants of both sexes, aged from 30 to 50 years, with a history of CRS lasting more than three months and clinical diagnostic criteria confirmation two or more main symptoms, or just one chief symptom (nasal blockage, pressure or soreness in the face, postnasal drip, and hyposmia) and two slight symptoms (headache, bad breath, exhaustion, tooth discomfort, and ear pain) and also confirmed by computed tomography (CT) scan outcomes [9].

Exclusion criteria

The exclusion criteria included the presence of any tumors or cysts (as proved by CT scan examination), nasal polyps, lesions on the face, illnesses, or allergies to the face, pregnancy, facial metal implants, previous surgery on the nose, and reduced heat perception (like uncontrolled type 2 diabetes), and deterioration of cognitive level.
Sample size calculation
The sample size was calculated prior to the experiment to eliminate type II error. The calculations were performed using the statistical tool G*Power 3.1.9.4 at α=0.05, β=0.2, and effect size=0.75. It was determined that the necessary sample size was n=62. The sample size was increased to 68 participants to account for the drop-off as shown in Fig. 1.

Randomization
Sixty-eight CRS patients were sorted into one of two groups at random: control (group A) or experimental (group B). The randomization was carried out by a statistician who was not involved in the data gathering and who used a computer-generated random number list. Sealable, sequentially numbered opaque envelopes were utilized to assure the secret allocation. The first author opened the envelopes and began the treatment, as directed by the group assignment. The second author, who was not aware of the group assignment, got the outcome measures. Participants were blinded because those in the control group were referred by an ENT specialist and only had two encounters with the researcher, once for pretest evaluation and once for posttest evaluation four weeks later. The participants in the control group did not match those in the experimental groups. Furthermore, the experimental group’s physiotherapy sessions were private, separate, and held on different days and times. As a result, the participants have never met or know each other. In addition, the investigator ensures that participants in the study group are unaware of particular elements of the study.

Intervention
The patients were divided into two equal groups at random (n=34). Group A (the control group) received just prescription medicine from an ENT doctor. Group B (experimental group) was treated with medicine by an ENT specialist and involved in a program of physiotherapy that included: (1) US therapy: Using Sonoplus 490 from Enraf-Nonius, the participants were instructed to lie on their backs with the therapist standing at head height. The patients underwent pulsed US (duty cycle 50%) therapy for the maxillary and frontal sinuses at intensities of 1 and 0.5 W/cm², respectively, and a 1 MHz collimating beam frequency with a 6:1 beam non-uniformity ratio, to deliver the US to the treatment area, A diminutive US applicator (0.8 cm²) with a 0.6 cm² effective radiating area was utilized. The skin around the cheeks was utilized during application for the maxillary sinus and the forehead for the frontal sinus. Between the applicator and the skin, use an ultrasonic transmission gel, each maxillary sinus had a full contact approach for 5 minutes, while each frontal sinus received a 4 minutes full contact approach [10]. (2) Manual drainage techniques: It is performed from a supine lying position, while the therapist is seated behind the patient’s head. (3) Self-sinus massage technique: Participants were also urged to self-massage their frontal and maxillary sinuses at home while reclining twice daily, in the morning and evening. Table 1 has a full explanation of all manual approaches [15-17,20,21]. Before the trial began, a demonstration session was conducted to present participants in the experimental group with a detailed explanation of the manual therapy technique. The physiotherapy program was applied three times a week (day after day) for twelve therapy sessions. The session started with US at the frontal sinuses then the maxillary sinuses followed immediately by manual drainage technique, the session lasted approximately 30 minutes.

Outcome measures
The measurable outcomes were assessed at baseline to 4 weeks
The therapist positioned the patient’s nose with the left thumb on the right side and the right thumb on the left side, the thumbs crossing above the bridge of the nose. Each thumb alternatively exerted pressure while moving down the nasal bone’s length seven times, then uncrossing the thumbs allowed for a bilateral sweeping motion that was repeated 7 times along the sides of the nose and out across the maxillae [16].

Maxillary sinus drainage technique
The therapist used the thumb to provide gradual increasing and released pressure down to the maxillary sinuses in a smooth rhythmic motion within the patient’s tolerable pain level, repeating 7 times. Then, drain the maxillary sinuses seven times with a sweeping motion from the maxillary sinuses down to just below the ears [17].

Self-sinus massaging technique
For the frontal sinus: The patient put his or her middle and index fingers just above the eyebrows on either side of the forehead, and performs gentle circular outward massaging for three sets of 30 seconds, repeated twice a day [20].
For the maxillary sinuses: On either side of the nose, the patient placed his or her middle and index fingers in the space between the cheekbones and the upper jaw, perform gentle circular outward massaging for three sets of 30 seconds, repeated twice a day [21].

RESULTS
The patients comprised 31 male (45.59%) and 37 female (54.41%) with a mean age of 38.40 years and a body mass index of 26.79 kg/m². The independent t-test revealed that there were no significant differences (p>0.05) among the groups regarding patients’ characteristics as shown in Table 2.

Wilcoxon signed-rank test indicated that there was a signifi-
cant reduction ($p<0.001$) in RSDI values for both groups when comparing the pretreatment values vs. the posttreatment values for each group as shown in Table 3. For control group (A), the physical disability index value decreased from 32.47±1.50 before treatment to 20.88±1.27 after treatment with a mean difference of 11.58 and the percentage of improvement was 35.66%, the functional disability index value also decreased from 19.03±1.44 before treatment to 12.88±1.34 after treatment with a mean difference of 6.14 and the percentage of improvement was 32.28%; the emotional disability index value decreased from 19.58±1.57 before treatment to 13.38±0.81 after treatment with a mean difference of 6.20 and the percentage of improvement was 31.66%, the total RSDI value decreased from 71.08±1.13 before treatment to 47.14±1.15 after treatment with a mean difference of 23.94 and the percentage of improvement was 33.68%.

While for the experimental group (B), the physical disability index value reduced from 32.88±1.37 before treatment to 14.17±1.33 after treatment with a mean difference of 17.91 and the percentage of improvement was 55.82%, the functional disability index value also reduced from 18.70±1.36 before treatment to 8.76±0.74 after treatment with a mean difference of 9.94 and the percentage of improvement was 53.15%, the emotional disability index value reduced from 19.82±1.48 before treatment to 8.82±0.86 after treatment with a mean difference of 11.00 and the percentage of improvement was 55.49%, the total RSDI value reduced from 70.64±1.20 before treatment to 31.76±1.04 after treatment with a mean difference of 38.88 and the percentage of improvement was 55.03%. The results revealed that the experimental group had a much higher percentage of improvement in RSDI values than the control group as shown in Table 3.

### Table 2. Patients’ characteristics

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=34)</th>
<th>Group B (n=34)</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>39.17±6.07</td>
<td>38.64±6.54</td>
<td>t=0.347, p=0.729</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75.97±4.58</td>
<td>76.26±4.11</td>
<td>t=0.278, p=0.781</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.24±4.17</td>
<td>169.15±2.85</td>
<td>t=1.051, p=0.297</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.93±1.61</td>
<td>26.66±1.46</td>
<td>t=0.080, p=0.936</td>
</tr>
<tr>
<td>Duration of symptoms (mo)</td>
<td>6.47±2.21</td>
<td>7.11±2.42</td>
<td>t=1.149, p=0.254</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16 (47.06)</td>
<td>15 (44.12)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>18 (52.94)</td>
<td>19 (55.88)</td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation or number (%). $p>0.05$ indicates no significance.

### Table 3. Wilcoxon signed-rank test and Mann–Whitney U-test for comparing rhinosinusitis disability index values within and between groups

**Wilcoxon signed-rank test within groups comparison**

<table>
<thead>
<tr>
<th>Variables RSDI</th>
<th>Control group (A)</th>
<th>Experimental group (B)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Mean difference (%)</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>32.47±1.50</td>
<td>20.88±1.27</td>
<td>11.58±1.33 (35.66)</td>
</tr>
<tr>
<td>Functional</td>
<td>19.03±1.44</td>
<td>12.88±1.34</td>
<td>6.14±0.43 (32.28)</td>
</tr>
<tr>
<td>Emotional</td>
<td>19.58±1.57</td>
<td>13.38±0.81</td>
<td>6.20±1.12 (31.66)</td>
</tr>
<tr>
<td>Total</td>
<td>71.08±1.13</td>
<td>47.14±1.15</td>
<td>23.94±0.95 (33.68)</td>
</tr>
</tbody>
</table>

**Mann–Whitney U-test between groups comparison**

<table>
<thead>
<tr>
<th>Variables RSDI</th>
<th>Pretest (control group vs. experimental group)</th>
<th>Posttest (control group vs. experimental group)</th>
<th>p-value of mean difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>$p=0.302$</td>
<td>$p&lt;0.001*$</td>
<td>$&lt;0.001*$</td>
</tr>
<tr>
<td>Functional</td>
<td>$p=0.359$</td>
<td>$p&lt;0.001*$</td>
<td>$&lt;0.001*$</td>
</tr>
<tr>
<td>Emotional</td>
<td>$p=0.408$</td>
<td>$p&lt;0.001*$</td>
<td>$&lt;0.001*$</td>
</tr>
<tr>
<td>Total</td>
<td>$p=0.131$</td>
<td>$p&lt;0.001*$</td>
<td>$&lt;0.001*$</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation. RSDI, rhinosinusitis disability index. $p>0.05$ indicates no significance, $^*p<0.05$ indicates significance.
The Mann–Whitney U-test showed no evidence of a significant difference (p>0.05) in RSDI values between both groups at the pretest conditions, while for the posttest conditions, there was a highly statistically significant decrease (p<0.001) in RSDI values in the experimental group in comparison to the control group as shown in Table 3. Moreover, there was a statistically significant difference (p<0.001) between both groups when comparing the change of the pre-post data values.

For control group (A), the change between the pretest and posttest values for physical disability index was 11.58±1.33, for functional disability index was 6.14±0.43, for emotional disability index was 6.20±1.12, for the total RSDI was 23.94±0.95. While for the experimental group (B), the change between the pretest and posttest values for the physical disability index was 17.91±1.11, for the functional disability index was 9.94±0.91, for the emotional disability index was 11.00±0.77, for the total RSDI was 38.88±0.67 as shown in Table 3.

The dependent t-test showed that there was a significant increase (p<0.001) in PPT values for both groups when comparing the pretreatment values vs. the posttreatment values for each group. For control group (A), the PPT of the right frontal sinus increased from 1.45±0.16 before treatment to 2.06±0.16 after treatment with a mean difference of 0.61 and the percentage of improvement was 42.06%, while the left frontal sinus PPT increased from 1.43±0.14 before treatment to 2.03±0.13 after treatment with a mean difference of 0.60 and the percentage of improvement was 41.95%. The PPT of the right maxillary sinus also increased from 1.90±0.11 before treatment to 2.57±0.10 after treatment with a mean difference of 0.67 and the percentage of improvement was 35.26%, while the left maxillary sinus PPT increased from 1.86±0.06 before treatment to 2.52±0.09 after treatment with a mean difference of 0.66 and the percentage of improvement was 35.48%.

While for the experimental group (B), the PPT of the right frontal sinus increased from 1.48±0.11 before treatment to 3.07±0.17 after treatment with a mean difference of 1.59 and the percentage of improvement was 107.43%, while the left frontal sinus PPT increased from 1.44±0.08 before treatment to 3.05±0.13 after treatment with a mean difference of 1.60 and the percentage of improvement was 111.80%. The PPT of the right maxillary sinus also increased from 1.87±0.10 before treatment to 3.21±0.15 after treatment with a mean difference of 1.33 and the percentage of improvement was 71.65%, while the left maxillary sinus PPT increased from 1.84±0.07 before treatment to 3.17±0.11 after treatment with a mean difference of 1.32 and the percentage of improvement was 72.47%. According to the findings, the experimental group's PPT values improved by a much greater percentage than those of the control group as shown in Table 4.

Independent t-test showed no significant difference (p>0.05) in PPT values between both groups at the pretest conditions, while for the posttest conditions, there was a highly statistically significant increase (p<0.001) in PPT values in the experimental group compared to the control group. Furthermore, there was a statistically significant difference (p<0.001) between both groups when comparing the change of the pre-post data values.

For control group (A), the change between the pretest and posttest values of the right frontal sinus PPT was 0.61±0.16 and it was 0.60±0.14 for the left frontal sinus PPT. Whereas, the right maxillary sinus PPT was 0.67±0.06 and it was 0.66±0.09 for the left maxillary sinus PPT. While for the experimental group (B) the change between the pretest and posttest values of the right frontal sinus PPT was 1.59±0.16 and it was 1.60±0.14 for the left frontal sinus PPT. Whereas, the right maxillary sinus PPT was 1.33±0.05 and it was 1.32±0.08 for the left maxillary sinus PPT as shown in Table 4.

**DISCUSSION**

The present study’s findings showed that the experimental group which received the physical therapy program in conjunction with conventional medical treatment demonstrated a highly statistically significant (p<0.001) enhancement in the measured outcomes after 4 weeks of treatment when compared to the control group that received only conservative medical therapy.

The current study’s findings supported the authors’ hypothesis that adding physical therapy programs including US therapy and manual therapy program to the traditional medical treatment was more effective than conventional medical treatment alone in treating patients with CRS in terms of QoL and PPT. QoL and pain enhancement can be attributed to a proposed strategy for the US that involves the breakdown of the biofilm structure of the bacterial population. The US was reported to reduce bacterial load by destroying biofilms [12]. Moreover, purulent discharge was frequently seen during or right after receiving US treatment. This could be because the US delivered mechanical energy to separate the purulent material from the sinus walls, relieving pressure and pain [28].

Pulsed US therapy for CRS patients has been shown to be sig-
significantly more efficient when combined with antibiotics, which can significantly reduce bacterial viability [28-31]. Additionally, 57 patients with CRS were successfully treated with low-intensity pulsed US. The investigators reported that the majority of both major and minor symptoms showed significant improvements following pulsed US therapy [32].

Other studies by Ansari et al. [8] showed a significantly larger decline in CRS symptoms following treatment with the US. Furthermore, when comparing pulsed and continuous therapeutic US, they did not identify any significant differences in outcomes between the two groups [9], however, pulsed US mode minimizes thermal activities by giving the coupling medium time to dissipate heat during treatment [33]. Another study included 20 patients who received six sessions of US three days per week. The severity of global sinonasal symptoms was evaluated after treatment using a 6-cm visual analog and the Sino-Nasal Outcome Test. Following treatment with the US, the patient’s total severity assessment scores improved [34].

One more case series study incorporates manual therapy into the overall management of CRS symptoms, and they found that patients who received a combination of local and regional manual therapy procedures, improved in all measured outcomes. There was a significant reduction in craniofacial pain and an increase in PPTs over four precise sinus points, as well as a reduction in the severity of symptoms. These findings seemed to compare more positively with outcomes seen in similar patients treated with antibiotics or endoscopic surgery [15].

The PPT was found to be significantly increased, as measured by pressure algometry on the frontal and maxillary sinuses. The positive effect could be attributed to the thermal effects produced at the sinuses as a result of the manual therapy intervention, which assisted in draining the excess secretions that cause inflammation to the adjacent lymph nodes. This technique, in turn, helped to reduce sinus inflammation and pain [35]. In agreement with our findings, Ahmadi et al. [20] indicated that massage therapy can be incorporated into an exercise program as a treatment modality in patients with CRS, based on the findings of their study, which revealed that a special face massage therapy protocol can relieve facial congestion and tenderness in CRS patients.

A five-session study combining US and shortwave diathermy interventions using manual drainage procedures and suboccipital release showed significant improvements in patients with chronic sinusitis. However, when compared to the shortwave

<table>
<thead>
<tr>
<th>Table 4. Dependent t-test and independent t-test for comparing pressure pain threshold values within and between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent t-test within groups comparison</strong></td>
</tr>
<tr>
<td>Variables PPT</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Right sinus</td>
</tr>
<tr>
<td>Pre</td>
</tr>
<tr>
<td>Post</td>
</tr>
<tr>
<td>p-value</td>
</tr>
<tr>
<td>Mean difference (%)</td>
</tr>
<tr>
<td>Left sinus</td>
</tr>
<tr>
<td>Pre</td>
</tr>
<tr>
<td>Post</td>
</tr>
<tr>
<td>p-value</td>
</tr>
<tr>
<td>Mean difference (%)</td>
</tr>
<tr>
<td><strong>Independent t-test between groups comparison</strong></td>
</tr>
<tr>
<td>Variables PPT</td>
</tr>
<tr>
<td>Frontal sinus</td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
</tr>
<tr>
<td>Maxillary sinus</td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Left</td>
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</tbody>
</table>

Values are presented as mean±standard deviation.
PPT, pressure pain threshold.
p>0.05 indicates no significance, *p<0.05 indicates significance.
diathermy group, the US therapy group experienced earlier and more rapid symptom reduction. As a result, the study recommended that US therapy would be applied as a treatment protocol for patients suffering from chronic sinusitis [19]. Thus, a novel approach to treating chronic sinusitis is currently being developed, which improves medical management and reduces antibiotic resistance, hence reducing the need for surgical surgery.

CRS has a similar negative influence on health as angina, chronic obstructive lung disorders, congestive heart failure, and low back pain [36]. Surgery is typically the next step after oral, topical, and antibiotic therapy. The establishment of a new paradigm in the treatment of CRS could result from the effective deployment of a physical therapy program. To the best of the authors’ knowledge, this is the initial research that evaluates the effect of adding US therapy to manual techniques using frontal, nasal, and maxillary sinus drainage, in addition to self-massage techniques and routine medical treatment.

This study was limited by the evaluation of improvement by CT in the area of para-nasal sinus, which might be a beneficial tool for the assessment of the anatomy and extent of improvement, thus more studies are recommended to evaluate the improvement by more additional assessment tools (sinuscopy and CT). In addition, only the short-term effect of the addition of a manual physical therapy program was evaluated, thus, long-term follow-up should be considered in further studies. Moreover, certain parameters of US were used in this study, different parameters will be recommended in future studies to assess their effects. In addition, further research is required to determine if manual techniques or US therapy plays a more important role in treating chronic instances of rhinosinusitis because the mixed physiotherapy program may not make clear which percentage of improvement was due to US therapy or manual techniques, so further study is needed to clarify this point. Furthermore, the sham US, sham sinus manual drainage techniques, and sham self-sinus massage weren’t given to the control group therefore future research should incorporate this type of intervention to improve study blinding. Also, this study was limited to a certain age group, therefore, more studies are recommended to assess the effect of different treatment periods of application on different categories of age.

In conclusion, according to the findings of this study, incorporating a physical therapy program that included pulsed US therapy, sinus manual drainage techniques, and self-sinus massage into conservative medical treatment was more effective than conservative medical treatment alone in improving QoL and PPT in CRS patients.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

FUNDING INFORMATION

None.

AUTHOR CONTRIBUTION

Conceptualization: Fouda KZ. Methodology: Fouda KZ, Eladl HM, Allam NM. Formal analysis: Fouda KZ, Ameer MA. Project administration: Fouda KZ, Eladl HM, Ameer MA, Allam NM. Visualization: Fouda KZ, Eladl HM, Ameer MA, Allam NM. Writing – original draft: Fouda KZ, Eladl HM, Allam NM. Writing – review and editing: Fouda KZ, Ameer MA. Approval of final manuscript: all authors.

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REFERENCES


Translation, Cultural Adaptation, and Validation of a Korean Version of the Information Needs in Cardiac Rehabilitation Scale

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Objective: To translate and culturally adapt the Information Needs in Cardiac Rehabilitation (INCR) questionnaire into Korean and perform psychometric validation.

Methods: The original English version of the INCR, in which patients are asked to rate the importance of 55 topics, was translated into Korean (INCR-K) and culturally adapted. The INCR-K was tested on 101 cardiac rehabilitation (CR) participants at Kangwon National University Hospital and Seoul National University Bundang Hospital in Korea. Structural validity was assessed using principal component analysis, and Cronbach's alpha of the areas was computed. Criterion validity was assessed by comparing information needs according to CR duration and knowledge sufficiency according to receipt of education. Half of the participants were randomly selected for 1 month of re-testing to assess their responsiveness.

Results: Following cognitive debriefing, the number of items was reduced to 41 and ratings were added to assess participants' sufficient knowledge of each item. The INCR-K structure comprised eight areas, each with sufficient internal consistency (Cronbach's alpha>0.7). Criterion validity was supported by significant differences in mean INCR-K scores based on CR duration and knowledge sufficiency ratings according to receipt of education (p<0.05). Information needs and knowledge sufficiency ratings increased after 1 month of CR, thus supporting responsiveness (p<0.05).

Conclusion: The INCR-K demonstrated adequate face, content, cross-cultural, structural, and criterion validities, internal consistency, and responsiveness. Information needs changed with CR, such that multiple assessments of information needs may be warranted as rehabilitation progresses to facilitate patient-centered education.

Keywords: Cardiovascular diseases; Cardiac rehabilitation; Needs assessment; Health knowledge, attitudes, practice; Surveys and questionnaires

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INTRODUCTION

Cardiovascular diseases (CVDs) represent a significant global health burden [1]. The implementation of secondary prevention strategies for CVDs has demonstrated remarkable effectiveness [2]. However, successful secondary prevention relies on patients’ knowledge and adoption of multiple health behavior changes [3]. Unfortunately, many patients do not achieve optimal risk reduction despite available interventions [4]. Therefore, it is crucial for healthcare providers to assess the information needs of cardiac patients to enhance treatment outcomes [5,6]. Nonetheless, accurately identifying patient information needs can be challenging for healthcare providers due to differences in perceived importance between clinical personnel and patients [7]. Moreover, patient information needs evolve over time, particularly as they transition back to their daily routines and incorporate various therapies [8]. Additionally, patient subpopulations may have diverse information needs based on factors such as sex, age, ethnicity, and socioeconomic status [7].

Extensive research has been dedicated to exploring patients’ information needs following various cardiovascular events, such as revascularization [9], acute coronary syndrome [10], post-myocardial infarction [8], and heart failure [11]. Surprisingly, limited attention has been given to investigating information needs in the context of cardiac rehabilitation (CR), despite patient education being a fundamental element of CR programs that aim to assist patients in implementing secondary prevention recommendations [12]. It is therefore recommended that an assessment of patient information needs be conducted prior to initiating patient education within CR, enabling the customization of educational interventions to meet individual needs and optimize outcomes [13].

In order to facilitate the identification of specific information needs in CR patients, a self-administered questionnaire called the Information Needs in Cardiac Rehabilitation (INCR; Appendix 1) was developed and subjected to psychometric validation in a Canadian context [14]. The INCR has since undergone translation and cultural adaptation for Chinese, Spanish, and Portuguese populations [15-17]. In the Korean setting, limited research has been conducted on the information needs of individuals with cardiac disorders. While several instruments have been developed in medically advanced countries since the 1990s to assess the information needs of cardiac patients [10], the availability of locally developed tools in this area remains scarce in Korea. To address this gap, a recent study aimed to translate the INCR questionnaire into Korean [18]. However, this study had certain limitations, particularly in terms of sample size, with only 45 participants, which was insufficient to establish the validity of the tool. Additionally, previous studies did not assess the construct and criterion validities of the translated INCR questionnaire.

The primary objective of the current study was to translate and culturally adapt the INCR tool for implementation in the Korean context and subsequently conduct a comprehensive psychometric validation involving a participant sample size of over 100 individuals. Furthermore, the study aimed to determine the participants’ highest priority information needs using the questionnaire.

METHODS

Design

This study was conducted in two stages. First, the INCR was translated and cross-culturally adapted into Korean version of the Information Needs in Cardiac Rehabilitation (INCR-K). Based on the COSMIN taxonomy [19], this first stage was to establish face, content, and cross-cultural validities of the scale. Face and content validities assess the extent to which a questionnaire accurately reflects its intended measurements. Several methods were employed to demonstrate face and content validities during translation, including cognitive debriefing, qualitative semi-structured interviews for feedback, and reviews conducted by an expert committee. The second step was the psychometric validation of the INCR-K through a cross-sectional survey, with repeated administration of the INCR-K in a random subsample. Structural validity, internal reliability, criterion validity, and responsiveness were assessed. This study was reviewed and approved by the Institutional Review Boards of Kangwon National University Hospital (IRB No. A-2022-01-005-002) and Seoul National University Bundang Hospital (IRB No. B-2207-769-303), and each participant provided informed written consent.

Materials

The INCR tool, developed and validated in English, assesses the information needs of patients undergoing CR. It consists of 55 items across 10 areas [14]. The 10 areas identified were the heart (physiology, symptoms, and surgical treatments), nutrition, exercise/physical activity, medication, work/vocational/social, stress/psychological factors, general/social concerns,
emergency/safety, diagnosis and treatment, and risk factors. Each item in the INCR-K, which assesses information needs, is rated on a 5-point Likert scale of 1 (really not important) to 5 (very important). The tool can be used to tailor educational interventions for patients undergoing CR, with higher scores indicating higher information needs. Furthermore, the tool can be used regardless of the CR participation duration.

**Translation and cross-cultural adaptation of the INCR**

The translation and cross-cultural adaptation of the INCR followed the Patient-Reported Outcomes Translation and Linguistic Validation Task Force guidelines by the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) [20], which include the following steps: (1) forward translation, (2) reconciliation, (3) back translation and review, (4) harmonization, (5) cognitive debriefing, (6) review of cognitive debriefing results and finalization, and (7) proofreading and final report.

Two independent translators (one was a medical doctor involved in the study and the other was not medical doctor) forward translated the INCR into Korean. Afterward, the two translations were reviewed for ambiguities, and any discrepancies were reconciled. Back translation was performed by two bilingual native English speakers fluent in Korean and blinded to the original English version. One translator was a healthcare provider, whereas the other was not.

An expert committee consisting of eight health professionals and translators compared the back translations to the original instrument for harmonization; in addition, the committee reviewed translations for linguistic, semantic, technical, and conceptual consistencies. This process resulted in the prefinal version of the INCR-K.

Regarding cognitive debriefing, the prefinal version was tested with five Korean patients from Kangwon National University Hospital receiving outpatient CR. The time required to complete the questionnaire was recorded, and patients were asked to provide feedback through qualitative semi-structured interviews. The patients were asked to rate the readability, length, and clarity of the questionnaire through 10 items, eight of which (Table 1) were rated through a visual analogue scale of 0–100 mm; 0 meaning not usable at all and 100 meaning very usable (i.e., higher scores denote more positive perceptions of the scale). These were analyzed using descriptive statistics. The remaining two questions (“If any of the questions in the survey are unclear, please tell us what they are” and “If any of the questions in the survey are duplicated, please tell us which one is the question”) were open-ended.

In the review of the input from cognitive debriefing by the expert committee, any ambiguous and redundant expressions were modified after a discussion. Finally, the refined version of the INCR-K was set for psychometric validation (Appendix 2).

**Psychometric validation**

**Participants**

In total, 104 patients were recruited from the CR programs at Kangwon National University Hospital and Seoul National University Bundang Hospital in Korea (Fig. 1). Seoul National University Bundang Hospital is situated in an urban locale, while Kangwon National University Hospital is located in a rural area. Sample size calculation for psychometric analysis was based on the recommendation of Hair et al. [21], which stipulates a minimum of 100 participants. The inclusion criteria consisted of patients diagnosed with CVDs who underwent CR between February 2022 and December 2022. Exclusion criteria encompassed individuals under the age of 18 years, those with literacy problems, and those with severe visual, cognitive, or mental impairments that hindered their ability to complete the question-
Seungsu Jeong, et al. Validation of the INCR-K

Dubbed as the Information Needs in Cardiac Rehabilitation (INCR-K), the instrument was utilized to gauge patients’ information needs upon enrollment. All participants underwent a cardiopulmonary exercise test or an electrocardiogram-monitored exercise session and completed the CR education schedule, as documented in their medical records. Participants completed the INCR-K questionnaire, and the scores of all items were averaged to determine the participants’ total information needs. In addition, the average score per area was calculated from participants who did not complete more than 20% of the items. Furthermore, the questionnaire was re-administered 1 month after the first administration to half of the patients who were randomly selected using a computer-generated sequence, and descriptive statistics were used to describe the INCR-K scores.

Measures
Participants completed the INCR-K questionnaire, and the scores of all items were averaged to determine the participants' total information needs. In addition, the average score per area was calculated from participants who did not complete more than 20% of the items. Furthermore, the questionnaire was re-administered 1 month after the first administration to half of the patients who were randomly selected using a computer-generated sequence, and descriptive statistics were used to describe the INCR-K scores.

Statistical analysis (psychometric validations and descriptive analysis)
Structural validity was assessed using principal component analysis. The suitability of the data for this analysis was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's sphericity test. KMO values >0.60 were considered acceptable, and a p-value <0.05 in Bartlett's sphericity test was considered significant. Areas with eigenvalues >1.0 were extracted according to the Kaiser-Guttman criterion. The matrix was interpreted using the varimax method with Kaiser normalization. Factor loading values >0.30 indicated representation in each area. The internal consistency of each area was calculated using Cronbach's alpha, and a value >0.7 was considered to reflect satisfactory internal correlation between items of the same area.

Criterion validity was assessed using a t-test to compare the total INCR-K score (the mean of all items) among patients with different CR durations. The duration of CR was defined as the period starting from the initial of CR session, which could consist of either a cardiopulmonary exercise test or an electrocardiogram-monitored exercise session, up to the point of the completing of the questionnaire. The categorization of CR duration into two groups (≤1 week and >1 week) was motivated in the intention to observe potential changes in information needs between initial and subsequent participants after starting CR. The choice of using 1-week threshold was informed by that the average duration of phase 1 in CR is less than 1–2 weeks. Furthermore, to assess the criterion validity of the newly introduced “knowledge sufficiency” scores, the INCR-K scores were compared to self-reported receipt of educational engagement.

To assess responsiveness, the questionnaire was re-administered 1 month after the first administration to half of the patients who were randomly selected using a computer-generated sequence. In our study, this 1-month interval was selected to correspond with the range of intervals (ranging from 3 weeks to 3 months) employed in previous studies. Subsequently, the INCR-K scores for each area in the first and second administrations were compared using t-tests.

Descriptive statistics were used to describe the INCR-K scores.
and determine whether patients had sufficient knowledge of each item. Data analysis was performed using IBM SPSS Statistics 25.0 (IBM Corp.). Statistical significance was set at p<0.05.

RESULTS
Translation and cultural adaptation
Forward translation, reconciliation, back translation, and harmonization
During the forward translation of the INCR from English to Korean, appropriate consideration was given to the cultural implications of the Korean honorifics. After back translation, the discrepancies between the original and back-translated versions were identified and resolved. During harmonization, the expert committee decided to remove three items from the original questionnaire (original INCR items 37, 38, and 41) [14] because of the differences in medical systems between Canada and Korea. Afterward, the resulting prefinal version, consisting of 52 items, was subjected to cognitive debriefing.

Cognitive debriefing
The prefinal version of the INCR-K was tested on five patients. The researchers maintained a neutral stance throughout the self-administration process, encouraging the participants to complete all the questions. The questionnaire was completed in an average of 7 minutes and 44 seconds. The results of the subsequent semi-structured interviews showed high ratings of the INCR-K in terms of usefulness (mean score, 81.2±13.9). In contrast, the INCR-K was rated as relatively difficult to read (59.0±36.4), lengthy (59.6±31.0), and possessing some unclear sentences (67.8±31.0; Table 1). During the interviews, some participants commented that the medical terminology in the prefinal version was difficult to understand. Other participants expressed dissatisfaction with the number of items, redundant content, and vague expressions in the questionnaire.

Review of cognitive debriefing results and finalization
After reviewing the results of cognitive debriefing, the expert committee and the developer of the original INCR (Sherry L. Grace) revised the prefinal version; the revisions were as follows: (1) Incomprehensible expressions were modified to make them easier to understand; (2) Items with redundant or less relevant content were deleted, thus reducing the total number of items from 52 to 41; and (3) Vague expressions were clarified. Details of each change are provided below.

Respondents in the cognitive debriefing phase commented that several items were difficult to understand, particularly the item “What is angioplasty?”, which is an unfamiliar medical term to many patients. To address this problem, the word “stent” was added, making it #6 "What is angioplasty and stent placement?". The term “stent” is a well-known term to patients.

To address the issue of length in the prefinal version and improve the overall readability of the questionnaire, we removed items that contained overlapping content. Three items regarding drug intake were identified to be similar; thus, the items “How do I remember to take my medication?” and “Are there foods I should avoid while taking these medications?” were deleted, leaving only item “How do I take my medication in the right way?” (INCR-K#21). Three items regarding stress were had overlapping content, and the items “How does stress affect my heart?” and “What can I do to reduce stress in my life?” were deleted, leaving only item “How can I cope with stress?” (INCR-K#27). Furthermore, two items on angina and chest pain were identified to have similar meanings, and the item “How do I recognize angina symptoms?” was deleted, leaving item “What should I do if I feel angina or chest pain?” (INCR-K#30) in the questionnaire. Three items regarding risk factors were similar in content; thus, the items “What are the risk factors that I cannot control?” and “What are the risk factors that I can control?” were deleted. The remaining item “What can I do to bring my risk factors under control?” (INCR-K#36) was retained. Finally, three similar items regarding tobacco use were evaluated and items “What are the benefits of quitting smoking?” and “What supports are available to help me quit smoking?” were deleted, leaving INCR-K#40, “How does tobacco affect the heart?” in the questionnaire.

Items with vague expressions were rephrased. For example, the item “When should I stop physical exercise?” was revised to “When should I stop exercise for safety?” (INCR-K#18) to better convey the intent of the question, which was to assess patients’ knowledge of the symptoms that should prompt the cessation of exercise during CR. To enhance clarity and comprehension, the item “What are the effects of complementary and alternative medications?” was revised to “Are complementary and alternative therapies (health supplements, Chinese medicine/acupuncture, massage, etc.) effective?” (INCR-K#23). This revision aimed to provide a clearer understanding of “complementary and alternative therapies.” To ensure the relevance of the questionnaire to the Korean context, specific examples such as “health supplements, Chinese medicine/acupuncture,
massage, etc.” were thoughtfully selected from two studies that specifically investigated the role of complementary and alternative treatments in CR [30,31]. These examples were carefully incorporated into the study to ensure that the questionnaire accurately reflected the Korean context. Finally, item “What feelings are common after a heart attack?” was revised to “What feelings are common after a heart attack? (Can I seek help if I feel depressed or anxious?)” (INCR-K#25) to clarify the intent of the question, which was to check for depression and anxiety that may occur after a heart attack.

Furthermore, to streamline the questionnaire, questions that were not applicable to all participants were excluded. This decision was primarily made to avoid an unnecessarily lengthy questionnaire, which could result in reduced response rates, respondent fatigue, and compromised data quality. Questions regarding specific topics such as preventing low blood sugar during exercise, caring for the feet during an exercise program, returning to an old job, or driving after a heart condition were removed. Instead, the questions focused on information needs relevant to a broader patient population, allowing for the development of a concise and efficient questionnaire. This approach improved the response rates and enhanced the overall quality of the collected data.

In the harmonization phase, two items were initially deleted because of differences between the Canadian and Korean medical systems. However, after revising the items to be appropriate for the Korean medical system, these two items were reintegrated into the INCR-K as “Is there a support system that can help patients with heart disease?” (INCR-K#29) and “When (in what cases) do I need to make an outpatient appointment or go to the emergency room?” (INCR-K#31). Initially, these questions were phrased as “What services, support organizations and groups are available?” and “When should I call the doctor?”, respectively.

Finally, in addition, respondents were asked to rate not only the importance of each item, but also whether they perceived they already had sufficient knowledge of the topic area (yes/no). Thus, in CR programs, the focus of the medical staff education can be on the areas where the patients require more knowledge. The total knowledge sufficiency score was calculated based on the percentage of “yes” responses for all items.

Proofreading and final report
The final version of the 41-item INCR-K is provided in Appendix 2.

Psychometric validation
Characteristics of the participants
Initially, 104 patients provided informed consent to participate in the study; however, three patients were excluded from the analysis owing to failure to answer any of the items in the INCR-K, resulting in a total of 101 participants included in the study. As shown in Table 2, the item completion rates were high.

Table 3 shows the sociodemographic and clinical characteristics of the participants. Half the participants had recently started receiving CR. Approximately half of the participants had received heart education, but less than 25% had received education regarding medication at the time of survey administration.

Factor analysis and internal consistency
Through translation and adaptation, the original 55 items of the INCR were reduced to 41 items in the final INCR-K. To assess structural validity, a factor analysis was conducted on the 41 items of the INCR-K using principal component analysis. The results showed that the data was suitable for factor analysis, with a KMO index of 0.824 (above 0.60) and a Bartlett’s test of sphericity of $\chi^2=2,880.63$ (p <0.001).

Eight areas were extracted, which accounted for 70.8% of the total variance. Table 4 presents the factor loading for the 41 items in the INCR-K. These areas included the heart, food and self-management, exercise, medication, emotion and return to previous roles, treatment and diagnosis, risk factors 1, and risk factor 2. The internal consistency of each area was assessed using Cronbach’s alpha of 0.73–0.88. All areas were considered internally consistent ($\alpha$>0.70), as shown in Table 4.

Criterion validity
As shown in Fig. 2A, the mean INCR-K scores were compared based on CR duration. For CR durations categorized as ≤1 week (n=51, 50.5%) and >1 week (n=50, 49.5%), the mean INCR-K scores were 4.27±0.49 and 4.51±0.32, respectively. The results showed that patients with a longer CR duration perceived information as more important (p=0.005). Among 51 patients who had CR duration ≤1 week, 32 were inpatients, while the remaining 19 were outpatients. All 50 patients with CR duration >1 week were all outpatients.

In addition, the criterion validity of the added knowledge sufficiency ratings was supported because the receipt of heart education was significantly related to these ratings of knowledge sufficiency (p<0.05), as shown in Fig. 3. Moreover, the criterion

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Table 2. INCR-K responses including information needs and knowledge sufficiency

<table>
<thead>
<tr>
<th>Area</th>
<th>Item</th>
<th>INCR-K information needs/ importance rating</th>
<th>Sufficient knowledge</th>
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<tbody>
<tr>
<td></td>
<td>Item score(^m) (mean±SD)</td>
<td>Item completion rate (%)</td>
<td>Yes (%)</td>
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<td></td>
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<td>Completion rate (%)</td>
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<td>The heart</td>
<td>1. How does a healthy heart work?</td>
<td>4.66±0.55</td>
<td>96.2</td>
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<td>2. What is &quot;coronary artery disease&quot;?</td>
<td>4.56±0.67</td>
<td>96.2</td>
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<td>3. What is angina?</td>
<td>4.50±0.61</td>
<td>97.1</td>
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<td>4. What happens when someone has a heart attack?</td>
<td>4.75±0.56</td>
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<td>5. What is &quot;bypass surgery&quot;?</td>
<td>4.27±0.88</td>
<td>93.3</td>
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<td>6. What is angioplasty and stent placement?</td>
<td>4.49±0.77</td>
<td>97.1</td>
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<td>Food and self-management</td>
<td>7. What foods should I eat for a healthy heart?</td>
<td>4.57±0.61</td>
<td>97.1</td>
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<td>8. How can I choose healthy foods at the grocery store?</td>
<td>4.21±0.74</td>
<td>97.1</td>
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<td>9. How can I choose healthy foods when dining out?</td>
<td>4.19±0.76</td>
<td>97.1</td>
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<td>10. How do I read food labels?</td>
<td>3.80±0.87</td>
<td>97.1</td>
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<td>11. How can I exercise at home safely?</td>
<td>4.24±0.74</td>
<td>97.1</td>
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<td>Exercise</td>
<td>11. How will exercise help my heart condition?</td>
<td>4.61±0.58</td>
<td>97.1</td>
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<td>12. What are the components of a safe exercise program?</td>
<td>4.51±0.70</td>
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<td>13. What is cardiovascular or aerobic exercise?</td>
<td>4.46±0.66</td>
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<td>14. How should I exercise in hot or cold weather?</td>
<td>4.35±0.76</td>
<td>96.2</td>
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<td>15. What is resistance training (i.e. exercise for strength)?</td>
<td>4.08±0.72</td>
<td>97.1</td>
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<td>16. What types of exercise equipment are available?</td>
<td>3.95±0.75</td>
<td>97.1</td>
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<td>17. How can I exercise at home safely?</td>
<td>4.24±0.74</td>
<td>97.1</td>
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<td>Medication</td>
<td>18. When should I stop physical exercise for safety?</td>
<td>4.57±0.59</td>
<td>97.1</td>
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<td>19. What medications do I need to help my heart?</td>
<td>4.50±0.67</td>
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<td>20. How do I take my medication in the right way?</td>
<td>4.57±0.62</td>
<td>97.1</td>
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<td>21. Which side effects are possible with my medication?</td>
<td>4.45±0.66</td>
<td>96.2</td>
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<td>22. Are complementary and alternative therapies (health supplements,</td>
<td>3.54±1.06</td>
<td>97.1</td>
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<td>23. What are the risk factors for heart disease?</td>
<td>4.46±0.66</td>
<td>97.1</td>
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<td>Emotion and return to</td>
<td>19. Is sexual activity safe for me?</td>
<td>3.76±1.01</td>
<td>96.2</td>
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<td>previous roles</td>
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<td>24. When can I return to work and to my old activities?</td>
<td>4.20±0.78</td>
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<td>25. What feelings are common after a heart attack?</td>
<td>4.15±0.84</td>
<td>97</td>
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<td>Treatment and diagnosis</td>
<td>26. How does stress affect my heart?</td>
<td>4.57±0.57</td>
<td>97.1</td>
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<td>27. How can I cope with stress?</td>
<td>4.40±0.63</td>
<td>97.1</td>
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<td>28. Do sleep problems affect my heart?</td>
<td>4.79±0.46</td>
<td>96.2</td>
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<td>29. What should I do if I feel angina or chest pain?</td>
<td>4.64±0.63</td>
<td>96.2</td>
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<td>30. When (in what cases) do I need to make an outpatient appointment</td>
<td>4.28±0.76</td>
<td>97.1</td>
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<td>31. When (in what cases) do I need to go to the emergency room?</td>
<td>4.43±0.64</td>
<td>97.1</td>
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<td>32. What are the tests used to diagnosis my heart condition?</td>
<td>4.47±0.63</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk factor 1</td>
<td>26. How does stress affect my heart?</td>
<td>4.65±0.54</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27. How does cholesterol affect my heart?</td>
<td>4.53±0.64</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28. How does diabetes affect my heart?</td>
<td>4.55±0.59</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29. How does physical inactivity affect my heart?</td>
<td>4.38±0.66</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk factor 2</td>
<td>29. Is there a support system that can help patients with heart</td>
<td>4.07±0.92</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>disease?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30. What are the risk factors for heart disease?</td>
<td>4.51±0.58</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31. How does tobacco affect my heart?</td>
<td>4.60±0.74</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32. How does alcohol affect my heart?</td>
<td>4.54±0.66</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4.38±0.43</td>
<td>99.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INCR-K, Korean version of the Information Needs in Cardiac Rehabilitation; SD, standard deviation.

\(^m\) Range, 1–5, with 5 being "very important."
Table 3. Socio-demographic and clinical characteristics of the participants and health care receipt

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value (n=101)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socio-demographic</strong></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
</tr>
<tr>
<td>Kangwon National University Hospital (rural)</td>
<td>60 (59.4)</td>
</tr>
<tr>
<td>Seoul National University Bundang Hospital (urban)</td>
<td>41 (40.6)</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>59.46±11.90</td>
</tr>
<tr>
<td>&lt;65</td>
<td>67 (66.3)</td>
</tr>
<tr>
<td>≥65</td>
<td>34 (33.7)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>82 (81.2)</td>
</tr>
<tr>
<td>Female</td>
<td>19 (18.8)</td>
</tr>
<tr>
<td>Work status</td>
<td></td>
</tr>
<tr>
<td>Paid job</td>
<td>63 (62.4)</td>
</tr>
<tr>
<td>Retired</td>
<td>22 (21.8)</td>
</tr>
<tr>
<td>No job</td>
<td>15 (14.8)</td>
</tr>
<tr>
<td>No response</td>
<td>1 (1.0)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Elementary school</td>
<td>11 (10.9)</td>
</tr>
<tr>
<td>Middle school</td>
<td>9 (8.9)</td>
</tr>
<tr>
<td>High school</td>
<td>31 (30.7)</td>
</tr>
<tr>
<td>University</td>
<td>38 (37.6)</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>11 (10.9)</td>
</tr>
<tr>
<td>No response</td>
<td>1 (1.0)</td>
</tr>
<tr>
<td>Monthly income (USD)</td>
<td></td>
</tr>
<tr>
<td>&lt;1,000</td>
<td>10 (9.9)</td>
</tr>
<tr>
<td>1,000–2,000</td>
<td>21 (20.8)</td>
</tr>
<tr>
<td>2,000–3,000</td>
<td>20 (19.8)</td>
</tr>
<tr>
<td>3,000–4,000</td>
<td>19 (18.8)</td>
</tr>
<tr>
<td>4,000–7,000</td>
<td>14 (13.9)</td>
</tr>
<tr>
<td>&gt;7,000</td>
<td>9 (8.9)</td>
</tr>
<tr>
<td>No response</td>
<td>8 (7.9)</td>
</tr>
<tr>
<td><strong>Clinical</strong></td>
<td></td>
</tr>
<tr>
<td>Risk factor</td>
<td></td>
</tr>
<tr>
<td>Family history</td>
<td>10 (9.9)</td>
</tr>
<tr>
<td>Tobacco use&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41 (40.6)</td>
</tr>
<tr>
<td>Sedentary lifestyle&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52 (51.5)</td>
</tr>
<tr>
<td>Obesity&lt;sup&gt;c&lt;/sup&gt;</td>
<td>44 (43.6)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>43 (42.6)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>23 (22.8)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>53 (52.5)</td>
</tr>
<tr>
<td>Low high-density lipoprotein</td>
<td>91 (90.1)</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>2 (2.0)</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>4 (4.0)</td>
</tr>
<tr>
<td>CR indication</td>
<td></td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>84 (83.2)</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>5 (4.9)</td>
</tr>
<tr>
<td>Heart failure</td>
<td>6 (5.9)</td>
</tr>
<tr>
<td>Peripheral artery disease&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3 (3.0)</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>3 (3.0)</td>
</tr>
<tr>
<td>Percutaneous coronary intervention</td>
<td>84 (83.2)</td>
</tr>
</tbody>
</table>

Values are presented as number (%) or mean±standard deviation. CR, cardiac rehabilitation.
<sup>a</sup>Current cigarette smokers or those who quit smoking within the previous 6 months or have been exposed to environmental tobacco smoke [37].
<sup>b</sup>Not participating in at least 30 minutes of moderate-intensity physical activity (40%–60% of oxygen consumption reserve) on at least 3 days of the week for at least 3 months [37].
<sup>c</sup>Body mass index≥25 kg/m<sup>2</sup>.
<sup>d</sup>Patients with peripheral artery disease had cardiovascular risk factors.

validity was supported because a longer CR duration corresponded to a higher knowledge sufficiency (p=0.04; Fig. 2B).

**Responsiveness**

Of the randomly selected participants, 10 did not complete the INCR a second time and three completed the second questionnaire after more than 3 months (Fig. 1). Fig. 4 displays the INCR-K item scores per area at the first and second administrations. All areas were rated as more important during the second administration. There was a significant difference in information needs according to time in the following areas: the heart, exercise, and treatment and diagnosis. Specifically, during the first test, patients were most interested in learning about “the heart” and “treatment and diagnosis.” However, during the second test, participants reported their greatest information needs to be related to “the heart” and “exercise.”

**Descriptive analysis of information needs and knowledge sufficiency and preferred educational delivery modes**

The mean INCR-K score on the first administration was 4.38±0.43, with 85.1% of all participants rating the importance of the informational items as high (INCR-K score≥4). The three items with the highest ratings were as follows: #30 “What should I do if I feel angina or chest pain?” (4.79±0.46), #4 “What happens when someone has a heart attack?” (4.75±0.56), and #1...
### Table 4. Principal component analysis of 41 items of the INCR-K

<table>
<thead>
<tr>
<th>Area</th>
<th>Item</th>
<th>Factor loading</th>
<th>Internal consistency (Cronbach's alpha)</th>
<th>Mean information needs score per area (mean±SD)</th>
<th>Knowledge sufficiency per area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The heart</strong></td>
<td>1. How does a healthy heart work?</td>
<td>0.687</td>
<td>0.88</td>
<td>4.54±0.70</td>
<td>59.1</td>
</tr>
<tr>
<td></td>
<td>2. What is &quot;coronary artery disease&quot;?</td>
<td>0.747</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. What is angina?</td>
<td>0.617</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. What happens when someone has a heart attack?</td>
<td>0.704</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. What is &quot;bypass surgery&quot;?</td>
<td>0.658</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. What is angioplasty and stent placement?</td>
<td>0.697</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Food and self-management</strong></td>
<td>7. What foods should I eat for a healthy heart?</td>
<td>0.546</td>
<td>0.87</td>
<td>4.16±0.78</td>
<td>54.5</td>
</tr>
<tr>
<td></td>
<td>8. How can I choose healthy foods at the grocery store?</td>
<td>0.785</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. How can I choose healthy foods when dining out?</td>
<td>0.744</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. How do I read food labels?</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16. What types of exercise equipment are available? (where?)</td>
<td>0.463</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17. How can I exercise at home safely?</td>
<td>0.505</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exercise</strong></td>
<td>11. How will exercise help my heart condition?</td>
<td>0.498</td>
<td>0.87</td>
<td>4.41±0.70</td>
<td>62.9</td>
</tr>
<tr>
<td></td>
<td>12. What are the components of a safe exercise program?</td>
<td>0.672</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. What is cardiovascular or aerobic exercise?</td>
<td>0.781</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14. How should I exercise in hot or cold weather?</td>
<td>0.562</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15. What is resistance training (i.e. exercise for strength)?</td>
<td>0.339</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35. What are the risk factors that I can control?</td>
<td>0.420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medication</strong></td>
<td>18. When should I stop physical exercise for safety?</td>
<td>0.548</td>
<td>0.77</td>
<td>4.33±0.83</td>
<td>48.4</td>
</tr>
<tr>
<td></td>
<td>20. What medications do I need to help my heart?</td>
<td>0.830</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21. How do I take my medication in the right way?</td>
<td>0.750</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22. Which side effects are possible with my medication?</td>
<td>0.708</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23. Are complementary and alternative therapies (health supplements, Chinese medicine/acupuncture, massage, etc.) effective?</td>
<td>0.416</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Emotion and return to previous roles</strong></td>
<td>19. Is sexual activity safe for me?</td>
<td>0.611</td>
<td>0.73</td>
<td>4.04±0.90</td>
<td>46.1</td>
</tr>
<tr>
<td></td>
<td>24. When can I return to work and to my old activities?</td>
<td>0.653</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25. What feelings are common after a heart attack? (Can I seek help if I feel depressed or anxious?)</td>
<td>0.649</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Treatment and diagnosis</strong></td>
<td>27. How can I cope with stress?</td>
<td>0.538</td>
<td>0.87</td>
<td>4.51±0.64</td>
<td>53.2</td>
</tr>
<tr>
<td></td>
<td>28. Do sleep problems affect my heart?</td>
<td>0.527</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30. What should I do if I feel angina or chest pain?</td>
<td>0.640</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31. When (in what cases) do I need to make an outpatient appointment or go to the emergency room?</td>
<td>0.741</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32. What are the tests used to diagnosis my heart condition?</td>
<td>0.537</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33. What treatments are available for my condition?</td>
<td>0.379</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36. What can I do to bring my risk factors under control?</td>
<td>0.613</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Risk factor 1</strong></td>
<td>26. How does stress affect my heart?</td>
<td>0.534</td>
<td>0.86</td>
<td>4.53±0.61</td>
<td>69.5</td>
</tr>
<tr>
<td></td>
<td>37. How does cholesterol affect my heart?</td>
<td>0.511</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38. How does diabetes affect my heart?</td>
<td>0.709</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39. How does physical inactivity affect my heart?</td>
<td>0.492</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Risk factor 2</strong></td>
<td>29. Is there a support system that can help patients with heart disease?</td>
<td>0.503</td>
<td>0.74</td>
<td>4.43±0.76</td>
<td>57.1</td>
</tr>
<tr>
<td></td>
<td>34. What are the risk factors for heart disease?</td>
<td>0.430</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40. How does tobacco affect my heart?</td>
<td>0.733</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41. How does alcohol affect my heart?</td>
<td>0.841</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INCR-K, Korean version of the Information Needs in Cardiac Rehabilitation; SD, standard deviation.
“How does a healthy heart work?” (4.66±0.55). Whereas, three items with the lowest information need were #23 “Are complementary and alternative therapies (health supplements, Chinese medicine/acupuncture, massage, etc.) effective?” (3.54±1.06), #19 “Is sexual activity safe for me?” (3.76±1.01), and #10 “How do I read food labels?” (3.80±0.87; Table 2).

Among the eight areas of the INCR-K, participants rated “the heart” and “risk factor 1” (e.g., stress, cholesterol, diabetes, and physical inactivity) as the most important information needs (4.54±0.70 and 4.53±0.61, respectively). Meanwhile, “emotion and return to previous roles” and “food and self-management” were rated as the lowest information needs (4.04±0.90 and 4.16±0.78, respectively; Table 4).

Table 2 presents knowledge sufficiency, expressed as the percentage of “yes” responses for each item. Knowledge sufficiency was 12.1%–82.8%. Specifically, the items with the highest knowledge sufficiency were #40 “How does tobacco affect my heart?”, #41 “How does alcohol affect my heart?”, and #11 “How will exercise help my heart condition?” Prior to psychometric validation, we hypothesized that items demonstrating higher knowledge sufficiency would indicate a reduced need for additional information. However, information needs remained high among participants with prior knowledge. The mean INCR-K score was 4.53±0.65 for participants with knowledge and 4.18±0.81 for those without knowledge (p<0.001).

Table 5 shows that the preferred method of educational delivery was face-to-face consultation with medical staff (53.5%). Conversely, the least preferred method was through audiovisual materials (4.0%).

**DISCUSSION**

Fulfilling the information needs of cardiac patients positively affects the patients’ quality of life, satisfaction with care, and health outcomes [6]. To effectively address these needs, healthcare providers must evaluate the information needs of patients with cardiac diseases participating in CR programs. To assess the information needs in Korea, we translated the original INCR into Korean, culturally adapted it, and validated its psychometric properties. An abridged version comprising 41 items was finalized. This revised version also incorporated knowledge sufficiency rating, which may prove helpful in the current era where many patients receive health information online. The results supported the face, content, cross-cultural, and criterion validities of the INCR-K as well as its internal reliability and responsiveness.

The INCR enables healthcare providers to effectively identify and address the information needs of patients undergoing CR, thus bridging the information gap between medical staff and patients and ultimately resulting in improved outcomes [5,6]. In a previous study, the original version of the INCR was employed to identify the information needs of patients and gaps in the educational curriculum of patients undergoing CR [32]. Modifying the curriculum based on these findings can enhance the effectiveness and efficiency of education. Hence, further studies in Korea are warranted to assess the effectiveness of implementing the INCR-K in patient education.

The results of this study agree with those of previous studies in some aspects but differ in others. First, similar to previous studies, this study established the criterion validity of INCR
Fig. 3. Total information needs (range, 1–5) (A–D) and knowledge sufficiency (range, 0%–100%) (E–H) by receipt of cardiac rehabilitation education, by topic. Perceived knowledge sufficiency was significantly related to previous receipt of heart education, but there were no differences in information needs, suggesting that patients understood the importance of the topics. Significant differences are indicated by asterisks (*p<0.05, **p<0.01, ***p<0.001).
Fig. 4. Comparison of information needs (range, 1–5) per area for the first and second tests, n=36. Significant differences are indicated by asterisks (*p<0.05, **p<0.01).

Table 5. Preferred education delivery mode

<table>
<thead>
<tr>
<th>Education Delivery Mode</th>
<th>Value (n=101)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-face consultation with medical staff</td>
<td>54 (53.5)</td>
</tr>
<tr>
<td>Internet resources</td>
<td>46 (45.5)</td>
</tr>
<tr>
<td>Smartphone apps</td>
<td>41 (40.6)</td>
</tr>
<tr>
<td>Booklets</td>
<td>34 (33.7)</td>
</tr>
<tr>
<td>Face-to-face lecture</td>
<td>33 (32.7)</td>
</tr>
<tr>
<td>E-learning</td>
<td>13 (12.9)</td>
</tr>
<tr>
<td>Audiovisual materials</td>
<td>4 (4.0)</td>
</tr>
</tbody>
</table>

Values are presented as number (%).

Based on CR duration [14,15]. Decker et al. [8] observed that as the duration of CR increased, there was a corresponding increase in patients’ information needs. Initially, patients depend heavily on the clinicians’ decisions, particularly when confronted with life-threatening situations. However, as the CR program progresses and their condition stabilizes, patients gradually become more involved in the decision-making process. Consequently, the increase in information needs is attributable to the growing number of questions related to decision making. According to Ghisi et al. [33], extended CR participation enhances knowledge sufficiency. Continuous engagement in a CR program allows patients to reinforce their knowledge through repeated training sessions.

Consequently, as the duration of CR increases, patients’ knowledge sufficiency improves. Second, the item (INCR-K#30) with the highest information needs was related to emergency and safety issues, which is consistent with the results of previous studies [6,34,35]. Emergency situations such as angina and heart attack were considered the most important, and this finding was consistent regardless of the stage of the patient in the CR program. Furthermore, it was observed that the “risk factor 1” area (e.g., stress, cholesterol, diabetes, and physical inactivity) demonstrated elevated information needs compared to other areas (Table 4). This finding aligns with those of previous studies reporting significant level of information need in this area [34,36]. The primary reason for heightened information needs in relation to risk factors may be attributable the intense fear of heart disease recurrence among individuals. This indicates that patients with a history of heart disease, particularly those who have had myocardial infarction, exhibit the highest level of concern regarding the possibility of recurrence and recognize the importance of managing risk factors for prevention [36].

Third, following translation and cultural adaptation, the number of items in the INCR questionnaire decreased from 55 to 41. Although these two areas were omitted, the overall structure of the INCR-K remained consistent with that of the original English version [14]. The initial version of the INCR encompasses 10 areas: heart, exercise/physical activity, medication, work/vocational/social, stress/psychological factors, general/social concerns, emergency/safety, diagnosis and treatment, risk factors, and barriers/goal setting. After translation and cultural adaptation, the INCR-K was created. It underwent a subsequent factor analysis, resulting in the identification of eight areas, namely heart, food and self-management, exercise, medication, emotion and return to previous roles, treatment and diagnosis,
risk factor 1, and risk factor 2. Despite the variation in area composition between the original INCR and INCR-K, both questionnaires share common areas such as Heart, Exercise, Medication, Treatment and diagnosis, and Risk factor; thus ensuring the overall consistency of the questionnaire.

This study has several implications. First, it highlights the need for direct knowledge assessment to determine knowledge sufficiency more accurately. In the INCR-K, knowledge sufficiency was evaluated indirectly by asking patients to provide “yes” or “no” responses. However, solely confirming knowledge without direct assessment does not guarantee a precise understanding of the information. Although healthcare providers should prioritize addressing information that patients consider important and areas in which their knowledge is lacking, ascertaining patients’ actual comprehension without direct assessment remains challenging. Therefore, it is essential to ensure that patients understand the information using direct assessment methods. Furthermore, a distinction was observed between the actual implementation of education and the patients’ perceptions of receiving education. All 101 patients (100%) had received education as documented in their medical records; however, only 14 of 101 patients (13.9%) reported that they had received the complete education. This discrepancy suggests that patients may not feel confident about receiving sufficient education, thus highlighting the need for continued educational efforts. We believe that enhancing the curriculum by reinforcing education that patients did not acknowledge will result in a more effective delivery of education. Finally, the findings of this study emphasize the importance of regularly assessing patient information needs throughout their CR program, as these needs may change over time. This continued assessment can ensure that information needs are met and support optimal patient self-management.

To ensure efficient patient education in clinical settings, it is crucial to prioritize two key areas: the “area with the highest information needs” and “area with the lowest knowledge sufficiency.” The area with the highest information needs corresponds to the topics that patients are most curious about, whereas the area with the lowest knowledge sufficiency relates to subjects that patients have the least understanding. Among the various areas examined, the “heart” area demonstrated the highest information needs, with a score of 4.54±0.70 (Table 4). This result can be attributed to the significance of heart disease and patients’ priority of acquiring information and knowledge related to their heart health.

Therefore, it is recommended to develop and implement educational programs that specifically focus on the “heart” area in clinical practice to enhance the knowledge of heart health. In contrast, the area of “emotion and return to previous roles” displayed the lowest knowledge sufficiency (Table 4). Patients’ lack of knowledge in this area is attributable to their perception of heart disease, primarily as a physical ailment, resulting in an insufficient understanding of the emotional challenges and importance of resuming their previous roles. Comorbid psychiatric disorders are prevalent in CR patients and significantly affect their quality of life [37]. Therefore, it is essential to incorporate regular psychiatric assessments into CR programs and provide robust support for patients to resume their previous roles [37].

This study had some limitations. First, although this study met the minimum sample size of 100 participants, as recommended by Hair et al. [21], the same authors suggested a minimum of five subjects per item for factor analysis, which would require 205 participants for the 41-item INCR-K. However, the assumptions were met for the factor analysis, and the solution converged, assuaging the sample size concerns. However, a larger sample size would be required to establish construct validity, although this has been established in other INCR versions; thus, any concerns in this regard would be minimal. In addition, this study was performed in only two regions of Korea. Future studies in other regions are warranted to establish generalizability.

In conclusion, the INCR-K questionnaire has satisfactory psychometric properties; hence, it can be used to assess the information needs of Korean patients undergoing CR. The results provide evidence of the face, content, cross-cultural, structural, and criterion validities, internal consistency, and responsiveness of the INCR-K. The INCR-K tool can support healthcare professionals in determining the information needs of patients undergoing CR. Therefore, education can be tailored to their individual needs.

**CONFLICTS OF INTEREST**

No potential conflict of interest relevant to this article was reported.

**FUNDING INFORMATION**

None.
AUTHOR CONTRIBUTION


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REFERENCES


Appendix 1. Original version of the Information Needs in Cardiac Rehabilitation (INCR) and preferences for educational delivery formats

Information Needs Assessment for Cardiac Rehabilitation Patients

You are being invited to fill out this questionnaire because you are in the cardiac rehabilitation program. Knowledge about your condition, treatments and risk factors is an important component about management. We would like to have a sense of how important a topic may be to increase your knowledge about heart disease as you have been recovering from your heart event.

The purpose of this questionnaire is to:
• assess your needs for information regarding heart disease;
• identify specific topics about your condition that you want to learn about;
• identify your preferences for educational delivery formats.

This questionnaire is confidential and completely voluntary. It should take about 10 minutes to complete.

Instructions for Completion:

1. Please answer as many items as you can;
2. Rate each topic on a 5-item scale related to ‘how important do you think this topic is to increase your knowledge about heart disease’;
3. After completing the questionnaire, please return to the researcher or reception.
4. If you do not wish to fill out the questionnaire, please leave it blank and place it in the collection box or return to the researcher.
**INFORMATION NEEDS ASSESSMENT IN CARDIAC REHABILITATION**

Rate the importance of each topic to increase your knowledge about coronary artery disease

<table>
<thead>
<tr>
<th>Topic</th>
<th>Really not important</th>
<th>Not important</th>
<th>Neutral</th>
<th>Important</th>
<th>Very Important</th>
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<tbody>
<tr>
<td>1. How does a healthy heart work?</td>
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<td>2. What is “coronary artery disease”?</td>
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<td>3. What is angina?</td>
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<td>4. What happens when someone has a heart attack?</td>
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<td>5. What is “bypass surgery”?</td>
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<td>6. What is an angioplasty?</td>
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<td>7. What foods should I eat for a healthy heart?</td>
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<td>8. How can I choose healthy foods at the grocery store?</td>
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<td>9. How can I choose healthy foods when dining out?</td>
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<td>10. How do I read food labels?</td>
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<td>11. How will exercise help my heart condition?</td>
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<td>12. What are the components of a safe exercise program?</td>
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<td>13. What is cardiovascular or aerobic exercise?</td>
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<td>14. What can I do to improve or maintain flexibility?</td>
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<td>15. How should I exercise in hot or cold weather?</td>
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<td>16. How do I prevent low blood sugar with exercise?</td>
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<td>17. How do I take care of my feet when in an exercise program?</td>
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<td>18. What is resistance training (i.e. exercise for strengthen)?</td>
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<td>19. What types of exercise equipment are available? (where?)</td>
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<td>20. How can I exercise at home safely?</td>
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<td>21. When should I stop physical exercise?</td>
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<td>22. Is sexual activity safe for me?</td>
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<td>23. What medications do I need to help my heart?</td>
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<td>24. How do I take my medication in the right way?</td>
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<td>25. Which side effects are possible with my medication?</td>
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<td>26. Do the medications I am taking interfere with each other?</td>
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<td>27. Are there foods I should avoid while taking these medications?</td>
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<td>28. What are the effects of complementary and alternative medications?</td>
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<td>29. When can I return to work and to my old activities?</td>
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<td>30. Can I go back to my same job?</td>
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<td>31. When can I start driving again?</td>
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<td>32. What feelings are common after a heart attack?</td>
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<td>33. How does stress affect my heart?</td>
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<td>34. How can I cope with stress?</td>
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<td>35. What can I do to reduce stress in my life?</td>
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<td>36. Do sleep problems affect my heart?</td>
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<td>37. What services, support organizations and groups are available?</td>
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<tr>
<td>38. What support services are available to my family?</td>
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<tr>
<td>39. How do I recognize angina symptoms?</td>
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<tr>
<td>40. What should I do if I feel angina or chest pain?</td>
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<td>41. When should I call the doctor?</td>
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<td>42. When should I call 911 or go to the emergency room?</td>
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</tbody>
</table>
INFORMATION NEEDS ASSESSMENT IN CARDIAC REHABILITATION

Rate the importance of each topic to increase your knowledge about coronary artery disease

<table>
<thead>
<tr>
<th>Question</th>
<th>Really not important</th>
<th>Not important</th>
<th>Neutral</th>
<th>Important</th>
<th>Very important</th>
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<tbody>
<tr>
<td>43. What are the tests used to diagnosis my heart condition?</td>
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<td>44. What treatments are available for my condition?</td>
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<td>45. What are the risk factors for heart disease?</td>
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<td>46. What are the risk factors that I cannot control?</td>
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<td>47. What are the risk factors that I can control?</td>
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<td>48. What can I do to bring my risk factors under control?</td>
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<td>49. How does cholesterol affect my heart?</td>
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<td>50. How does diabetes affect my heart?</td>
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<td>51. How does physical inactivity affect my heart?</td>
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<td>52. How does smoking affect my heart?</td>
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<td>53. What are the benefits of quitting smoking?</td>
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<tr>
<td>54. What supports are available to help me quit smoking?</td>
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<tr>
<td>55. How does alcohol affect my heart?</td>
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</tbody>
</table>

What other topics would you like to describe?

PREFERENCES FOR EDUCATIONAL DELIVERY FORMATS

How would you prefer this information to be delivered?
You can mark as many options as you want.

1. Printed book ☐
2. Internet Resources (website, videos) ☐
3. E-learning module (recorded lectures, slides) ☐
4. Lectures ☐
5. Audio: CD or “podcast” ☐
6. Discussion during consultations with healthcare provider ☐
7. Movies and videos that I can bring to home ☐

Other ideas for formats of education that you think would be helpful?

Thanks for your participation!
Appendix 2. Korean version of the Information Needs in Cardiac Rehabilitation (INCR-K)

감정재활 대상 환자들이 알고 싶어하는
교육주제 설문조사

심장질환의 적절한 자기관리를 위하여 모든 심장질환 환자는 자신의 상태나 치료 및 위험인자에 대해서 잘 알고 있어야 합니다. 이 설문지는 귀하께서 심장질환에 대해 알고자 할 때, 어떤 정보를 얼마나 알고 싶어 하는지를 조사하기 위하여 시행됩니다.

이 설문지의 목적은 다음과 같습니다.

• 심장 질환에 대해 어떤 정보를 필요로 하는지 확인합니다.
• 귀하의 상태에 대해 알고 싶은 특히 알고 싶어하는 정보가 무엇인지 확인합니다.
• 선호하는 교육 방식을 확인합니다.

이 설문지는 자발적이며 원하지 않으시면 설문을 중단할 수 있습니다.

총 문항은 심장 재활에 대한 정보의 중요성 평가항목 41개,
교육 전달 방식에 대한 선호도 항목 7개로 소요시간은 약 10분입니다.

작성 지침

1. 가능한 한 많은 항목에 응답해 주세요.
2. 각 항목마다 해당 내용이 '심장 질환에 대한 지식을 높이는 데 얼마나 중요하다고 생각'하는지를 5단계의 척도로 평가해 주세요.
3. 설문지 작성 후 담당자에게 연락 주시기 바랍니다.

작성일: ________________
심장재활 대상 환자들이 알고 싶어하는 교육주제 설문조사

심장질환에 대한 당신의 지식을 늘리기 위해서, 각 항목의 정보가 얼마나 중요한지 (혹은 필요한지)를 평가해주세요.
또한 이미 각 질문을 잘 알고 있는 지를 ‘예 ’ ‘아니오‘로 표시해주세요.

<table>
<thead>
<tr>
<th>번호</th>
<th>주제</th>
<th>전혀 중요하지 않음</th>
<th>중요하지 않음</th>
<th>보통</th>
<th>중요함</th>
<th>매우 중요함</th>
<th>이미 이 내용을 잘 알고 있다.</th>
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<tbody>
<tr>
<td>1.</td>
<td>건강한 심장은 어떻게 작동하는가?</td>
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<td>예 아니오</td>
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<td>2.</td>
<td>&quot;관상동맥질환&quot;이란 무엇인가?</td>
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<td>&quot;협심증&quot;이란 무엇인가?</td>
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<td>4.</td>
<td>심장마비가 발생하면 어떻게 되는가?</td>
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<td>5.</td>
<td>&quot;관상동맥우회로 이식술(bypass surgery)&quot;이란 무엇인가?</td>
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<td>6.</td>
<td>&quot;봉선후창술(angioplasty)&quot; ”스텐트(stent)시술”이란 무엇인가?</td>
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<td>7.</td>
<td>건강한 심장을 위하여 어떤 음식을 먹어야 하는가?</td>
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<td>8.</td>
<td>식료품 가게에서 건강에 좋은 식품을 고르는 방법은 무엇인가?</td>
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<td>9.</td>
<td>식사할 때 건강에 좋은 식사를 고르는 방법은 무엇인가?</td>
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<td>10.</td>
<td>식품 포장에 붙어 있는 영양성분표시는 어떻게 읽는가?</td>
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<td>11.</td>
<td>운동은 심장에 어떤 도움이 되는가?</td>
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<td>12.</td>
<td>심장에 안전한 운동은 어떻게 하는가?</td>
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<td>13.</td>
<td>심혈관 운동 또는 유산소 운동이란 무엇인가?</td>
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<td>14.</td>
<td>덥거나 추울 때는 운동을 어떻게 해야 하는가?</td>
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심장재활 대상 환자들이 알고 싶어하는
교육주제 설문조사

심장질환에 대한 당신의 지식을 늘리는 것이 필요하기 위해서, 각 항목의 정보가 얼마나 중요한지 (혹은 필요하지)를 평가해주세요.
또한 이미 각 질문을 잘 알고 있는지를, '예' '아니오'로 표시해주세요.

|    | 전히 중요하지 않음 | 중요하지 않음 | 보통 | 중요함 | 매우 중요함 | 이미 이 내용을 잘 알고 있다.
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<td>15</td>
<td>저항 훈련(즉, 근력 운동)은 어떻게 하는가?</td>
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<td>16</td>
<td>어떤 종류의 운동기구들이 유용한가? (어디서 운동할 수 있는가?)</td>
<td>☐</td>
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<tr>
<td>17</td>
<td>어떻게 하면 집에서도 안전하게 운동할 수 있는가?</td>
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<td>18</td>
<td>운동 중 안전을 위해 운동을 중단해야 하는 경우는?</td>
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<td>19</td>
<td>성행위는 나에게 안전한가?</td>
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<td>20</td>
<td>건강한 심장을 위하여 내게 어떤 약들이 필요한가?</td>
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<td>21</td>
<td>올바른 약물 복용법은?</td>
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<td>22</td>
<td>약물 복용으로 어떤 부작용이 생길 수 있는가?</td>
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<td>23</td>
<td>보완대체치료(건강보조식품, 한약/침술, 마사지 등)는 효과가 있는가?</td>
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<td>24</td>
<td>언제쯤 직장(원래 하던 일)과 이전 수준의 활동으로 돌아갈 수 있는가?</td>
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<td>25</td>
<td>심장마비 후 보통 어떤 감정이 드는가? (기분이 우울하거나 불안하면 도움을 받을 수 있는가?)</td>
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<td>26</td>
<td>스트레스는 심장에 어떤 영향을 주는가?</td>
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<td>27</td>
<td>심장 건강을 위해 스트레스에 어떻게 대처해야 하는가?</td>
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<td>28</td>
<td>수면장애는 심장에 어떤 영향을 주는가?</td>
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<td>29</td>
<td>심장질환 환자에게 도움이 될 만한 지원제도가 있는가?</td>
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심장질환에 대한 당신의 지식을 늘리기 위해서, 각 항목의 정보가 얼마나 중요한지 (혹은 필요하지)를 평가해주세요.
또한 이미 각 질문을 잘 알고 있는지, '예' '아니오'로 표시해주세요.

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<th>전혀 중요하지 않은</th>
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<th>보통</th>
<th>중요함</th>
<th>매우 중요함</th>
<th>이미 이 내용을 잘 알고 있다.</th>
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<tbody>
<tr>
<td>30. 협심증이 의심되거나 흉통이 느껴지면 어떻게 해야 하는가?</td>
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<td>31. 언제(어떤 경우에) 의례 진료를 예약하거나 응급실에 가야 하는가?</td>
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<td>32. 심장 상태를 평가하기 위하여 시행되는 검사들은 어떤 것들이 있는가?</td>
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<td>33. 내가 받을 수 있는 치료에는 무엇이 있는가?</td>
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<td>34. 심장질환의 위험 인자는 무엇인가?</td>
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<td>35. 심장재활이란 무엇인가?</td>
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<td>36. 심장질환의 위험 인자를 조절하려면 어떻게 해야 하는가?</td>
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<td>37. 콜레스테롤이 심장에 어떤 영향을 미치는가?</td>
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<td>38. 고혈압이 심장에 어떤 영향을 미치는가?</td>
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<td>39. 신체 활동 부족이 심장에 미치는 영향은 무엇인가?</td>
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<td>40. 담배가 심장에 어떤 영향을 미치는가?</td>
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<td>41. 음주가 심장에 어떤 영향을 미치는가?</td>
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심장 질환을 잘 관리하기 위해서 더 알고 싶은 다른 주제가 있나요?
### Appendix 3. Preferences for educational delivery formats (Korean version)

교육 방식에 대한 선호도

교육이 어떻게 제공되기를 원하십니까?
중복해서 선택할 수 있습니다.

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<td>1.</td>
<td>책자</td>
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<td>2.</td>
<td>인터넷 자료(웹사이트, 동영상)</td>
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<td>3.</td>
<td>스마트폰 앱(어플리케이션)</td>
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<td>4.</td>
<td>E-러닝 (동영상 강의, 강의 슬라이드)</td>
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<td>5.</td>
<td>대면 강의</td>
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<td>6.</td>
<td>오디오 자료: CD, 오디오 방송(&quot;팟캐스트&quot;)</td>
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<td>7.</td>
<td>의료진과의 대면 상담</td>
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교육 제공 방식에 대한 보다 좋은 아이디어가 있으신가요?

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INTRODUCTION

Japan has one of the fastest aging populations worldwide. The number of heart failure patients in Japan, especially among older adults, is rapidly increasing [1]. The main clinical features of heart failure include physical inactivity with fatigue, shortness of breath, and mental distress [2]. In older adults, heart failure leads to a decreased tolerance for exercise, and eventually to an impairment in the ability to perform activities of daily living (ADL) [3,4]. A meta-analysis of the prevalence of ADL impairment in heart failure patients revealed that Japan had the highest prevalence at 58.2% [5]. In older inpatients, medical triggering events or complications, such as a decline in mobility and function due to bed rest [6] and hospitalization-associated disability, may occur due to less light-intensity physical activity [7]. Older inpatients may be treated in a convalescent rehabilitation ward to prevent physical decline, avoid prolonged bed rest, improve the performance of ADL, and establish independent living [8].

Physical Activity and Activities of Daily Living in Older Adult Patients With Heart Failure Admitted for Subacute Musculoskeletal Disease

Tomoko Shimizu, RPT, MSc¹,², Chiaki Kanai, OTR, MSc¹,², Keisuke Ueda, MD, PhD¹, Yasuyoshi Asakawa, PhD²

¹Department of Rehabilitation, The Anti-Tuberculosis Association, Shin-Yamanote Hospital, Tokyo, Japan
²Department of Physical Therapy, Graduate School of Human Health Science, Tokyo Metropolitan University, Tokyo, Japan

Objective: To examine activities of daily living (ADL) and physical activity in older adults with heart failure admitted to a rehabilitation ward for subacute musculoskeletal disease.

Methods: This study included patients with musculoskeletal disease (aged ≥75 years) who were admitted to the rehabilitation ward. Data on age, ADL, and time for physical activity (metabolic equivalents [METs]) were collected. Patients were divided into groups with or without heart failure, and the differences were compared using Mann–Whitney U-test.

Results: This study included 84 musculoskeletal patients, including 25 with heart failure. The heart-failure group had similar levels of ADL independence compared to the without-heart-failure group (p=0.28) but had shorter duration of continuous and sustained physical activities and less total time (p<0.01) of light-intensity physical activity or higher.

Conclusion: Older adults with subacute musculoskeletal disease with heart failure do not necessarily require a large amount of physical activity to maintain ADL at the time of discharge. But very low physical activity may increase the risk for developing hospitalization-associated disability. Physical activity in older adults with subacute musculoskeletal disease with heart failure should be monitored separately from ADL.

Keywords: Activities of daily living, Heart failure, Aged, Sedentary behavior, Musculoskeletal disease
According to the Ministry of Health, Labor and Welfare [9], in people aged 75 years and older, symptoms due to decline in physiological function and the ability to perform ADL increase, and comprehensive management of symptoms of multiple chronic diseases is important. The prevalence of multiple chronic diseases is expected to increase in patients with heart failure, in particular in patients with musculoskeletal disease, where incidence increases with age [10]. Patients with chronic heart disease have altered function of the myosin molecule in skeletal muscle, resulting in muscle weakness, reduced physical activity level and ability to maintain balance [11], and increased risk for falls [12]. Gerber et al. [13] reported that in chronic heart failure patients older than 80 years, the incidence of femur fracture is 2.3-times higher in male and 4.18-times higher in female than that in patients without heart failure. Rahman et al. [14] reported that in older adults with chronic heart failure, osteoarthritis was 25% higher in male and 20% higher in female than that in those without heart failure.

For inpatients with musculoskeletal disease with femur fractures and knee osteoarthritis, rehabilitation through an interdisciplinary care program, focusing on physical exercise, is generally provided to improve motor function and ADL compromised by orthopedic injury to the best extent [15,16], which is required to assess the patient's independence in ADL and physical activities during hospitalization. It is predictable that physical activity may inevitably be limited in patients with heart failure. It is not well known whether the independence in ADL is actually low and how much physical activity is low among older adult musculoskeletal disease patients with heart failure admitted to a convalescent rehabilitation ward.

The purpose of this study was to investigate independence in ADL and physical activities with heart failure patients aged 75 years and older who were admitted to a convalescent rehabilitation ward due to subacute musculoskeletal disease, and to compare them with or without heart failure patients.

METHODS

Setting
This cross-sectional study was conducted between February 2020 and April 2021 in a 16-bed recovery rehabilitation ward attached to a secondary emergency hospital in Tokyo, Japan, which consisted of seven inpatient departments, 18 outpatient departments, and five 180-bed wards.

The applicable diseases, services, and duration of stay for convalescent rehabilitation wards are based on the medical fee determined by the government. The convalescent rehabilitation fee in the medical fee system ranges from 1 to 6, depending on the facility’s standards. Differences in facility standards include the number of staff, availability of rehabilitation services on holidays, percentage of severe disease patients, and achievement quotas. Hospitalization fee-1 has the highest allocation of human resources and the highest achievement quota. The facility standard in this study was Hospitalization fee-5.

The facilities also provide treatment by specialists in each department for each of the complex diseases during hospitalization in the convalescent rehabilitation wards. For example, respiratory disease is treated by respiratory specialists, cardiovascular diseases by cardiology specialists, and gastrointestinal diseases by gastroenterology specialists, while liver, renal, allergic, and metabolic diseases including diabetes are treated by general internal medicine specialists, and mental disorders by psychosomatic medicine and clinical psychologists, forming a team for each patient. Pain is treated immediately after admission and continuously with oral and transdermal analgesics depending on the pain level and chronic disease status by an orthopedic surgeon and/or internist. Patients with severe conditions requiring treatment, such as patients with respiratory, hepatic, or renal disorders and patients with New York Heart Association (NYHA) functional classification class-III or higher [17] are treated in the acute care unit, not transferred to the convalescent rehabilitation ward. The heart failure patients included in this study were those who were diagnosed with heart failure in other departments and transferred to the convalescent rehabilitation unit, and due to the conditions of the convalescent rehabilitation hospital, NYHA class-II patients were of the majority. Patients were assessed by the attending physician and those with stable heart failure symptoms and able to tolerate practicing ADL were allowed to be transferred to the convalescent rehabilitation ward for the primary purpose of practicing ADL, even if their subjective symptoms were categorized as NYHA class-III. Patients received personalized one-on-one rehabilitation with a therapist for 1–2 hours per day during the rehabilitation hours. Personalized rehabilitation includes basic action practice, strength training, ADL, gait practice, and endurance exercise. In the presence of many comorbidities, the guidelines followed the general principle of exercise prescription, which states that “a combined exercise regimen consisting of aerobic exercise, resistance training, balance training, and flexibility exercises should be considered to improve exercise
capacity and physical function [18], under the judgment and direction of the attending physician. This facility surveyed physical activity in patients aged 75 years and older who were hospitalized for musculoskeletal diseases and examined the data on physical activity at discharge.

Participants
The participants were subacute musculoskeletal patients admitted to the recovery rehabilitation ward. Subacute phase in this study is defined as the period from the day of transfer to the rehabilitation ward to the day of discharge. The patient’s transfer was permitted by the attending physician based on a combination of factors, including removal of the indwelling bladder catheter, no signs of wound infection, and the ability to take the required amount of food orally. Musculoskeletal disease is defined as the applicable conditions for admission to the convalescent rehabilitation ward, as follows: fractures of the femur, pelvis, vertebra, hip joints, knee joint, and hip joint replacement or knee joint replacement. The inclusion criteria for participants were as follows: (1) ≥75 years of age; (2) those who provided consent to participate in the study; and (3) a musculoskeletal disease applicable for admission to the convalescent rehabilitation ward. The exclusion criteria were as follows: (1) an admission diagnosis of a condition other than musculoskeletal disease; (2) comorbid disorders, long-term fever symptoms, and limitations in therapeutic or medical activities due to lower limb load restriction; (3) a mental state that would impair decision-making regarding participation in the study, including delirium; and (4) unstable mental or physical conditions and a high possibility of a sudden change in short-term physical conditions, judged by the physician upon admission into the ward.

Sample size
The required sample size was set at 80 participants using G*power (https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower) as follows: Wilcoxon–Mann–Whitney test (two groups), two tails, effect size 0.5, a err prob 0.05, power (1-β err prob) 0.5, and an allocation ratio of 2/1.

Ethics
This study was approved by the Institutional Review Board of The Anti-Tuberculosis Association, Shin-Yamanote Hospital (No. 19001) and by the research ethics committee of the Tokyo Metropolitan University, Arakawa Campus (No. 20038). Participants were informed of the content and purpose of the study verbally and in writing, and they provided written informed consent.

Data collection
Participant characteristics data
Potential confounders included age, sex, body mass index (BMI), length of hospital stay, ability to perform ADL, type of musculoskeletal disease diagnosed on admission, medical history, and mobility. Predictors included the presence of a history of heart failure. Outcomes were bout duration and the total time of physical activity classified by activity intensity. For patients with heart failure, the data on cardiac function variables were collected as patient characteristics.

Age, sex, BMI, length of hospital stay, the ability to perform ADL, musculoskeletal disease diagnoses, cardiac function variables, medical history, and mobility at discharge were collected from patient medical records. BMI was calculated by dividing the weight (kg) by height² (m²). To assess the ability to perform ADL, the Functional Independent Measure (FIM) was selected as the evaluation index. FIM compares movement ability objectively independent of the patient’s use of assistive devices, such as wheelchairs, walkers, canes, and railings, or communication skills, such as hearing, vision, verbal comprehension, and non-verbal comprehension. FIM quantifies the amount of ADL assistance provided to the patient and consists of 13 motor and five cognitive items on a 7-point scale ranging from 7 to 1 each, for a total score of 126 to 18 [19,20]. The data on FIM scores were collected from the medical records of entry and discharge conferences and were assessed by the ward nurses. “FIM at entry” was assessed within 24 hours of entry to the ward, and “FIM at discharge” was assessed the day before discharge. Preadmission indoor mobility was examined after admission based on the Living Space Assessment (LSA) [21]. The patients’ level of independence according to the LSA level-3 categories “been to a neighborhood other than their yard or apartment during the past four weeks,” and “needs help from others” were classified in our study as “personal assistance,” while “equipment only,” and “no equipment or personal assistance” were classified as “unassisted.” For indoor mobility at the time of discharge, locomotion was assessed under the FIM motor domain and “walking” or “wheelchair” scores were collected for assessment. Walking with a cane or walker was classified as “walking,” and those who were unable to walk 50 m (FIM walking score≤4) were classified as “wheelchair users” regardless of whether they were independent
wheelchair users. The musculoskeletal diseases that caused hospitalization were identified and recorded upon admission to the convalescent rehabilitation wards. A medical history of diabetes was included as patient characteristic variable because its incidence correlates inversely with the amount of physical activity [22]. The diagnosis of diabetes mellitus was based on hemoglobin A1c levels, ongoing treatment, and diagnostic history in the medical record. History of cerebrovascular disease was included as a patient characteristic variable because its sequelae are considered to increase the risk for reduced physical activity and ADL impairment [23]. The diagnosis of cerebrovascular disease was based on the medical history of previous stroke and cerebral hemorrhage, regardless of the severity of sequelae or the regular prescriptions. All study participants with a history of cerebrovascular disease were in the living phase of the disease, more than 6 months after disease onset.

Heart failure in this study was defined as having a diagnosis of heart failure, being on cardiovascular medication, and subjective symptoms with NYHA functional class-II or higher [17] prior to the onset of musculoskeletal disease: NYHA class-I, no symptoms with normal physical activity and function status; NYHA class-II, mild symptoms with normal physical activity, comfortable at rest, slight limitation of functional status, clinically walking more than two blocks on the level and climbing more than one flight of ordinary stairs, and performing to completion of any activity requiring 5 metabolic equivalents (METs); NYHA class-III, moderate symptoms with less than normal physical activity, comfortable only at rest, marked limitation of functional status, clinically walking one to two blocks on the level and climbing one flight of stairs, and patient can perform to completion of any activity requiring >2 METs; and NYHA class-IV, severe symptoms with features of heart failure with minimal physical activity and even at rest, severe limitation of functional status [17,24]. The research facility is a specialized rehabilitation ward for musculoskeletal diseases, and as a rule, does not accept patients in NYHA class-III or higher.

Division into groups with or without heart failure
Participants with the diagnosis of heart failure among patients with musculoskeletal disease were assigned to “with heart failure” group. Participants who were never diagnosed with heart failure, regardless of how many diseases they had, were assigned to the “without heart failure” group. Cardiac function indices of participants with heart failure were collected for presenting participant characteristics, as follows: brain natriuretic peptide (BNP) (pg/mL) which reflect worsening or improving hemodynamics, left ventricular ejection fraction (LVEF) (%), E velocity divided by A-wave velocity (E/A ratio), average E velocity divided by mitral annular e’ velocity (average E/e’), septal e’ velocity (cm/s), and tricuspid regurgitation (TR) velocity (m/s) as an echocardiographic parameter when investigating the cause of heart failure [25]. BNP test and echocardiography are not part of the usual practice for musculoskeletal disease. They are performed only when risk screening for cardiac function is appropriate at the start of musculoskeletal disease treatment. Subsequent echocardiographic testing was not performed. The conditions of participants with heart failure are assessed by BNP levels and clinical findings as needed.

Measurements
Accelerometer-measured physical activity
Physical activity was measured by attaching a triaxial accelerometer (Active Style Pro HJ750c; OMRON HEALTHCARE Co., Ltd) to the participant’s waist. For the device, the validity and reliability of the measurements compared to expiratory gas analysis and doubly labeled water method has been shown for physical activity under free-living, including walking and non-ambulatory activities (such as reading, office work, and cleaning) [26-28]. Based on physical activity measurement methods in patients with heart failure from previous studies, the period of wear was initiated at least 4 days prior to discharge and comprised 24 consecutive hours, excluding bathing, for at least 3 days [29]. Data were analyzed for 15 hours during the day, from the wake-up time at 6:00 to the lights-out time at 21:00, based on the schedule of the facility. If the acceleration signal was zero for more than 120 minutes in a 15-hour period, it was considered as non-attached [30], and the corresponding day was excluded from the analysis as missing data. The data of patients with valid 3-day records were analyzed.

Physical activity intensity was expressed in METs. Activity intensity was classified according to sedentary behavior (1.0–1.5 METs), light-intensity physical activity (1.6–2.9 METs), and moderate-to-vigorous intensity physical activity and higher (≥3.0 METs) [31]. Activity intensity was calculated for light-intensity physical activity or higher (≥1.6 METs) and moderate-to-vigorous-intensity physical activity or higher (≥3.0 METs). For example, 1.5 METs: sitting, knitting, sewing; 2.0 METs: walking at less than 2.0 mph on level ground; 2.5 METs: light cleaning (dusting, straightening up, changing linen, and carrying out trash); 3.0 METs: walking at 2.5 mph; 3.5 METs:
standing, packing boxes, occasional lifting of household materials; and 3.8 METs: walking at 3.5 mph [31].

The data processing procedure for physical activity was as follows: (1) Activity intensity was compiled into time series on a Microsoft excel sheet at 10-s intervals by the data reading application of the used device. (2) Total activity time was calculated by counting the number of cells for each activity intensity. (3-1) “Single continuous period” was defined as the time when bout cells of the same activity intensity continued, and the value and frequency of occurrence of each were calculated. (3-2) “Single continuous period per hour” was used in the analysis for the longest value that occurred at least 45 times during the 45 hours of measurement in 3 days. For example, during the 45-hours, if 90-second single continuous period occur 5 times and 100-second single continuous period occur 40 times, since the 90-second single continuous period is included in the 100-second single continuous period, we use the value of 90-second single continuous period in the analysis.

Patients who required care in wearing and removing the device when changing clothes were assisted by ward and rehabilitation department staff, to prevent data loss due to forgetting to wear the device.

Statistical analysis

Participant characteristics data

The distribution of data for age, BMI, length of stay, and FIM scores were examined for normality using Shapiro–Wilk test, and descriptive statistics were performed. The analysis using non-parametric tests is as follows. To compare differences in BNP data between entry and discharge, Wilcoxon signed-rank test was used. To compare differences between with heart failure and without heart failure groups, Mann–Whitney U-test was used for continuous scale data, and χ² test or Fisher’s exact test was used for sex, medical history, and mobility. As an analysis using parametric tests, the difference in change in FIM with and without heart failure was examined using two-way ANOVA.

Physical activity

The physical activity data distribution was checked using the Shapiro–Wilk test, and descriptive statistics were performed. To compare differences between with heart failure and without heart failure groups, the Mann–Whitney U-test was used with non-parametric tests. Effect size indices were examined for the non-parametric test, r (=Z/√N, Z: test statistic), and for the chi-squared test, φ. For additional analysis with parametric tests, multiple regression analysis forced entry method was used to extract risk factors, with physical activity as the dependent variable and patient characteristics variable as the independent variable. Next, repeated measures analysis of covariance (ANCOVA) was performed with the patient characteristics variable extracted as a risk factor as the covariate and the independent variable as the presence of heart failure.

Statistical analysis were performed using IBM SPSS Statistics 26 (IBM Corp.) and the significance probability was 5%.

RESULTS

Participant characteristics

A total of 84 participants were included in the study, including 25 with heart failure. No one failed to finish the study due to exacerbation of heart failure during the study period. The number of participants in each phase of the study is shown in the flowchart in Fig. 1. The descriptive statistics for all participants were as follows: age, 85 years (80.8–89.0 years) (median [interquartile range, 25th percentile–75th percentile]); female patients, 63 (75.0%), BMI, 20.5 (18.3–24.0) kg/m²; duration of stay in the recovery rehabilitation ward, 30.5 (20.0–50.3) days; FIM at entry, 85.5 (72.0–96.0) points; FIM at discharge, 108.0 (96.5–117.0) points; number of patients with postoperative femur fracture, 38 (45.2%); number of patients under treatment for diabetes mellitus, 27 (32.1%); number of patients with a history of cerebrovascular disease, 12 (14.3%); number of patients with independent indoor mobility prior to admission due to musculoskeletal disease, 74 (88.1%); and number of patients discharged ambulatory, 78 (91.7%; Table 1).

No differences were found for all variables of participant characteristics between the with heart failure and without heart failure groups: age, sex, BMI, days from onset of musculoskeletal disease to ward transfer, length of ward stay, FIM at entry, type of orthopedic disease, diabetes mellitus, cerebrovascular disease, and mobility at predmission and discharge (p=0.44, p=0.28, p=0.47, p=0.16, p=0.29, p=0.08, p=0.10, p=0.32, p=0.77, p=0.14, and p=0.11, respectively; Table 1). Similarly, no difference was found in FIM at discharge between the with heart failure group (108.0 [86.0–113.0] points) and without heart failure group (109.0 [97.5–117.0] points; p=0.28; Table 1). There was no statistical significance in the results of multivariate analysis of the difference in FIM score change between entry and discharge with and without heart failure (two-way ANOVA, p=0.40; Table 1). Risk factors affecting physical ac-
Fig. 1. This image presents a flowchart of study participant selection. IQR, interquartile range; BMI, body mass index; FIM, Functional Independent Measure; NYHA, New York Heart Association; min, minimum; max, maximum.

activities were age and FIM at discharge (Table 2). Clinical data on cardiac functions for participants with heart failure BNP decreased from 124.5 (72.6–221.8) pg/mL at admission to 76.4 (42.7–182.5) pg/mL at discharge, but not significantly (p=0.11). LVEF was 67.0% (60.0%–72.0%; Table 3). Fourteen of the 25 patients had diastolic dysfunction and three had systolic and diastolic dysfunction. Other patients with heart failure had atrial fibrillation and tachyarrhythmia and were on drug therapy. Patients underwent outpatient treatment at home and had stable cardiac function. The study defined heart failure by NYHA classification based on subjective symptoms and drug therapy, the NYHA classification II and III and comprised 20 (80.0%) and 5 (20.0%) patients, respectively. Five participants of NYHA class-III were diagnosed with occasional complaints of palpitations and fatigue, but usually had only mild subjective symptoms.

**Physical activities**

Descriptive statistics for all physical activities were 180 (130–
Table 1. Characteristics of participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All (n=84)</th>
<th>With heart failure (n=25)</th>
<th>Without heart failure (n=59)</th>
<th>p-value a),b),c)</th>
<th>Effect size a),b),c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>85.0 (80.8–89.0)</td>
<td>86.0 (80.0–91.0)</td>
<td>85.0 (81.0–87.5)</td>
<td>0.44 d)</td>
<td>0.08 d)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>20.5 (18.3–24.0)</td>
<td>20.2 (17.8–22.7)</td>
<td>21.6 (19.0–24.4)</td>
<td>0.47 e)</td>
<td>0.08 e)</td>
</tr>
<tr>
<td>Days from onset to admission to the rehabilitation ward (day)</td>
<td>13.0 (9.8–17.0)</td>
<td>15.0 (9.0–26.0)</td>
<td>13.0 (10.0–15.0)</td>
<td>0.16 d)</td>
<td>0.23 d)</td>
</tr>
<tr>
<td>Days for the rehabilitation ward (day)</td>
<td>30.5 (20.0–50.3)</td>
<td>34.0 (23.0–64.0)</td>
<td>29.0 (20.0–44.5)</td>
<td>0.29 e)</td>
<td>0.11 e)</td>
</tr>
<tr>
<td>FIM (point)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At entry</td>
<td>85.5 (72.0–96.0)</td>
<td>76.0 (60.0–96.0)</td>
<td>86.0 (76.0–96.0)</td>
<td>0.08 d)</td>
<td>0.15 d, f)</td>
</tr>
<tr>
<td>At discharge</td>
<td>108.0 (96.5–117.0)</td>
<td>108.0 (86.0–113.0)</td>
<td>109.0 (97.5–117.0)</td>
<td>0.28 d)</td>
<td>0.19 d, f)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>21 (25.0)</td>
<td>4 (16.0)</td>
<td>17 (28.8)</td>
<td>0.28 b)</td>
<td>0.14 b)</td>
</tr>
<tr>
<td>Female</td>
<td>63 (75.0)</td>
<td>21 (84.0)</td>
<td>42 (71.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative femur fracture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative femur fracture</td>
<td>38 (45.2)</td>
<td>15 (60.0)</td>
<td>23 (39.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other than postoperative femur fracture</td>
<td>46 (54.8)</td>
<td>10 (40.0)</td>
<td>36 (61.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative knee joint replacement</td>
<td>22</td>
<td>2</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservative treatment for osteoporotic compression fracture</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative osteoporotic compression fracture</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative spinal canal stenosis</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative hip joint replacement</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>27 (32.1)</td>
<td>10 (40.0)</td>
<td>17 (28.8)</td>
<td>0.32 b)</td>
<td>0.11 b)</td>
</tr>
<tr>
<td>History of cerebrovascular disease</td>
<td>12 (14.3)</td>
<td>4 (16.0)</td>
<td>8 (13.6)</td>
<td>0.77 b)</td>
<td>0.04 b)</td>
</tr>
<tr>
<td>Preadmission indoor mobility—unassisted</td>
<td>74 (88.1)</td>
<td>20 (80.0)</td>
<td>54 (91.5)</td>
<td>0.14 b)</td>
<td>0.16 b)</td>
</tr>
<tr>
<td>Indoor mobility at discharge—ambulation</td>
<td>78 (92.9)</td>
<td>21 (84.0)</td>
<td>56 (94.9)</td>
<td>0.11 b)</td>
<td>0.18 b)</td>
</tr>
</tbody>
</table>

Values are presented as median (interquartile range [25th percentile–75th percentile]), number (%), or number only. Min, minimum; Max, maximum; FIM, Functional Independent Measure.

a)Mann–Whitney U-test, b)chi-squared test, c)Fisher’s exact test, d)Z/√N, and, e)Analysis of the difference in FIM score change between entry and discharge with and without heart failure by two-way ANOVA, p=0.40.

220) seconds for a single continuous period of light-intensity physical activity or higher, 15 (10–20) seconds of moderate-to-vigorous-intensity physical activity or higher, 14,913.4 (10,569.2–19,502.5) seconds total time of light-intensity physical activity or higher, and 633.4 (354.6–927.5) seconds total time of moderate-to-vigorous-intensity physical activity or higher (Table 4). Descriptive statistics for physical activity in the group with heart failure were 130 (120–200) seconds for a single continuous period of light-intensity physical activity or higher, 10 (10–20) seconds for moderate-to-vigorous-intensity physical activity or higher, 11,296.6 (8,603.3–16,186.7) seconds total time of light-intensity physical activity or higher, and 383.3 (296.7–613.3) seconds total time of moderate-to-vigorous-intensity physical activity or higher (Table 4). Descriptive statistics for physical activity in the without heart failure group were 190 (150–220) seconds for a single continuous period of light-intensity physical activity or higher, 20 (10–20) seconds of moderate-to-vigorous-intensity physical activity or higher,
### Table 2. Analysis of risk factors for physical activities

<table>
<thead>
<tr>
<th>Factor</th>
<th>Physical activities</th>
<th></th>
<th></th>
<th>Total time</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single continuous period</td>
<td>Total time</td>
<td>Adjusted R(^2)</td>
<td>p-value</td>
<td>Standardized coefficients</td>
<td>Adjusted R(^2)</td>
</tr>
<tr>
<td></td>
<td>≥LIPA</td>
<td>MVPA</td>
<td>≥LIPA</td>
<td>MVPA</td>
<td>≥LIPA</td>
<td>MVPA</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.038*</td>
<td>0.77</td>
<td>0.25</td>
<td>0.55</td>
<td>0.029*</td>
<td>0.20</td>
</tr>
<tr>
<td>Sex</td>
<td>0.17</td>
<td>0.31</td>
<td>0.12</td>
<td>0.33</td>
<td>0.002*</td>
<td>0.3</td>
</tr>
<tr>
<td>Age</td>
<td>0.007*</td>
<td>-0.3</td>
<td>0.65</td>
<td>0.06</td>
<td>0.031*</td>
<td>-0.23</td>
</tr>
<tr>
<td>FIM at discharge</td>
<td>0.002*</td>
<td>0.3</td>
<td>0.12</td>
<td>0.21</td>
<td>&lt;0.001*</td>
<td>0.4</td>
</tr>
<tr>
<td>Days for recovery ward</td>
<td>0.44</td>
<td>0.63</td>
<td>0.06</td>
<td>0.30</td>
<td>0.0</td>
<td>0.10</td>
</tr>
<tr>
<td>Chronic heart failure</td>
<td>0.007*</td>
<td>-0.3</td>
<td>0.35</td>
<td>-0.11</td>
<td>0.020*</td>
<td>-0.23</td>
</tr>
<tr>
<td>Postoperative femur fractures</td>
<td>0.014*</td>
<td>0.1</td>
<td>0.50</td>
<td>-0.01</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.28</td>
<td>0.97</td>
<td>0.08</td>
<td>0.52</td>
<td>0.08</td>
<td>0.88</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>0.85</td>
<td>0.51</td>
<td>0.16</td>
<td>0.38</td>
<td>0.55</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Multiple linear regression forced-entry method was used for analysis; outcomes were physical activities; factors were sex, age, FIM at discharge, days for recovery ward, chronic heart failure, postoperative femur fractures, diabetes mellitus, and cerebrovascular disease.

LIPA, light-intensity physical activity; MVPA, moderate to vigorous physical activity; FIM, Functional Independent Measure.

*\(p<0.05\).

### Table 3. Clinical data on cardiac function in patients with heart failure

<table>
<thead>
<tr>
<th>NYHA functional classification</th>
<th>Value</th>
<th>Minimum</th>
<th>Maximum</th>
<th>p-value(^a)</th>
<th>Effect size(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>20 (80.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>5 (20.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>0 (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Parameters of cardiac function

- **BNP (pg/mL)**
  - At admission: 124.5 (72.6–221.8) pg/mL, 10.0 pg/mL, 800.0 pg/mL
  - At discharge: 76.4 (42.7–182.5) pg/mL, 11.6 pg/mL, 555.0 pg/mL
- **LVEF (%)**
  - 67.0 (60.0–72.0)%
  - 36.0%
  - 81.0%
- **Average E/e’**
  - 13.6 (10.4–16.6)
  - 7.1
  - 28.4
- **E/A**
  - 0.7 (0.6–0.9)
  - 0.5
  - 3.4
- **Septal e’ velocity (cm/s)**
  - 5.0 (4.5–7.0)
  - 3.0
  - 8.0
- **TR velocity (m/s)**
  - 2.3 (1.9–2.5)
  - 1.6
  - 3.4

Values are presented as number (%) or median (interquartile range [25th percentile–75th percentile]).

NYHA, New York Heart Association; BNP, brain natriuretic peptide; LVEF, left ventricular ejection fraction; Average E/e’, average E velocity divided by average mitral annular e’ velocity; E/A, E velocity divided by A-wave velocity; TR, tricuspid regurgitation.

\(^a\)Wilcoxon signed-rank test and \(^b\)\(r=Z/\sqrt{N}\).

15,273.3 (12,270.0–20,546.7) seconds total time of light-intensity physical activity or higher, and 730 (538.4–1,071.7) seconds total time of moderate-to-vigorous-intensity physical activity or higher (Table 4).

Between the with heart failure and without heart failure groups, differences were found in single continuous period of light-intensity physical activity or higher (\(p=0.005\)), moderate-to-vigorous-intensity physical activity or higher (\(p=0.004\), moderate-to-vigorous-intensity physical activity or higher (\(p=0.019\)), total activity time of light-intensity physical activity or higher (\(p=0.005\), and moderate-to-vigorous intensity physical activity or higher (\(p<0.001\)). The heart failure group had a shorter duration of physical activity for all variables in univariate analysis (Table 4). Age and FIM were selected as risk factors of physical activity according to the results of multiple regression analysis (Table 3). The single continuous period for light-intensity physical activity or higher was shorter in the heart failure group in the multivariate analysis with age and FIM as covariates (Table 4).
DISCUSSION

The purpose of this study was to investigate independence in ADL and physical activities with heart failure patients aged 75 years and older who were admitted to a convalescent rehabilitation ward due to subacute musculoskeletal disease and to compare them with or without heart failure patients. The heart failure patients included in this study were those who were diagnosed with heart failure in other departments and transferred to the convalescent rehabilitation unit, and due to the conditions of the convalescent rehabilitation hospital, NYHA class-II patients were of the majority. This study showed that patients with heart failure had no significant differences in ADL but did have differences in physical activity compared to patients without heart failure.

The characteristics of cardiac function in the heart failure group in this study were three as follows: most were of NYHA class-II with minimal subjective impairment in ADL; left ventricular ejection rate was preserved as indicated by the LVEF values; their heart overload was slightly high according to the BNP values, although the cause of admission was musculoskeletal disease. BNP values did not change statistically significantly during hospitalization, indicating that cardiac overload remained unchanged. In this study, there was no difference in the level of independence in ADL at entry and discharge between musculoskeletal disease patients with heart failure and those without heart failure. Limitations of ADL were considered likely to have been determined by musculoskeletal disease rather than heart failure. In older adult patients, the number and combination of multiple morbidities and the difficulties they face in their daily lives differ with each person. It is assumed that in the convalescent rehabilitation ward, support and facilitation to maximize the patient’s ADL functions are performed depending on the patient’s individuality. The ADL at the time of discharge were considered to be the result of demonstrating actual ADL as a patient of subacute musculoskeletal disease.

The single continuous period of physical activity in this study was 180 seconds for light-intensity physical activity or higher. The reported average walking time of hospitalized older adults was <2 minutes per observation period [32]. Light-intensity physical activity or higher includes walking, slow walking, and ADL and basic actions that occur back and forth associated with walking [33]. Therefore, the operation durations measured in this study were considered reasonable. For the total time of physical activity, participants in the study were 75 years and
older, with an average age of 85 years. A systematic review of physical activity in hospitalized adults of 25–85 years of age with musculoskeletal disease reported that inpatients spent 76%–99% of their time supine or inactive [34]. The activity time, 1%–24%, was calculated to be 0.24–5.76 hours per 24 hours. Considering that the participants in this study were aged 75 years and older and not fully independent in ADL, the total activity time indicated in this study of 14,913 seconds (4.1 hours) was considered reasonable. It has been reported that the walking time of hospitalized older adults with geriatric disease is 10 minutes at discharge [35]. The results of this study showed that a total duration of 633 seconds (10.6 minutes) of moderate-to-vigorous physical activity was equivalent to “walking,” which supported the findings of the previous study.

There were no differences between the participant characteristics variables for patients with and without heart failure. Therefore, it was considered that heart failure affected the difference in shorter physical activity. In general, for patients with subacute musculoskeletal disease, the more physical activity they have, the better their ADL. However, the results showed that participants with heart failure did not necessarily require greater amounts of physical activity to maintain ADL. There may be appropriate values for the physical activity duration for each patient with heart failure, regardless of the independence level of ADL. Regarding the difference in the duration of physical activity with and without heart failure, we consider that some kind of hypometabolism or muscle degeneration might be related to the amount of physical activity. Dysfunction of brawn adipose tissue (BAT) has been shown to occur with heart failure [36], and BAT has been reported to play an important role in metabolism and sarcopenia [37]. Secondary sarcopenia (disease-related sarcopenia) associated with heart failure [38] has been shown to result in atrophy of slow twitch muscle [39]; in contrast, age-related sarcopenia results in atrophy of fast twitch muscle [40]. The lower level of physical inactivity in heart failure patients may be different from the physical inactivity that occurs with aging or musculoskeletal disease. Although the patient’s ADL may improve while preventing overwork and exacerbation of heart failure, if the total amount of physical activity is extremely low, older adult patients may develop hospitalization-associated disability and have a worse prognosis after discharge. For patients with heart failure, it is considered necessary to first gauge the adequacy of the individual’s capacity for cardiac workload (single continuous period and total duration of activity). Elucidation of this point is considered to be a goal of future research. In older adults with heart failure and subacute musculoskeletal disease, physical activity should be monitored separately from independence in ADL.

Limitations
We used the longest continuous time per hour with an epoch length of a 10-s bout as the single continuous period in the analysis; therefore, the results may differ depending on how the single continuous period is defined. The accuracy of the accelerometer may vary with activity outcomes such as step, type of activity, limb position, and in populations with low mobility. The validity and reliability of non-free-living activities, such as exercises during rehabilitation period, remains unclear. Therefore, researchers should be cautious when applying the activity monitor to new populations or activities where the accuracy of the device has not been specifically tested. One selection bias of this study was that the facility conducting this research was situated within a general hospital. At the time of a scheduled admission or an emergency admission, patients with complex diseases other than musculoskeletal disease may intentionally select a hospital that can provide more comprehensive care. This may have induced bias in participants’ medical history in this study. As for the other medical history (such as chronic obstructive pulmonary disease, liver disease, renal disorder, dementia, and joint disease), it was assumed that a certain number of patients had been diagnosed or had completed or discontinued treatment at other hospitals in the past or had not undergone checkups and had not been diagnosed. Our medical records did not cover this disease entirely; these missing data may have provided the information bias and were not included in the medical history variable. But these diseases are considered to be an urgent issue to be investigated. For physical activity in older adults, environmental factors should also be considered, such as area of residence, facility equipment, family members living together, and their caregiving ability, in addition to individual factors, such as motivation and life history.

CONFLICTS OF INTEREST
No potential conflict of interest relevant to this article was reported.

FUNDING INFORMATION
None.
AUTHOR CONTRIBUTION

Conceptualization: Shimizu T, Kanai C. Methodology: Shimizu T, Ueda K, Asakawa Y. Formal analysis: Shimizu T, Asakawa Y. Project administration: Shimizu T, Kanai C. Visualization: Shimizu T. Writing – original draft: Shimizu T, Kanai C. Writing – review and editing: Shimizu T, Ueda K, Asakawa Y. Approval of final manuscript: all authors.

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REFERENCES

Instructions for authors

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1. AIMS & SCOPE

Annals of Rehabilitation Medicine (ARM) is the official journal of the Korean Academy of Rehabilitation Medicine. It is an international, peer-reviewed open access journal, which aims to be a global leader in sharing up-to-date knowledge dedicated to the advancement of care and enhancing the function and quality of life of persons with various disabilities and chronic illnesses. As the official journal of one of the largest societies of rehabilitation medicine in Asia and Oceania, nearly 8,000 physiatrists receive this journal every two months as a member benefit. This journal is endorsed by the International Society of Physical and Rehabilitation Medicine (ISPRM) and the Asia-Oceanian Society of Physical and Rehabilitation Medicine (AOSPRM). International members comprise approximately half the editorial board and conduct peer-review of submitted manuscripts.

The journal encompasses all aspects of physical medicine and rehabilitation, including clinical practice, experimental and applied research, and education. Research areas covered by this journal include rehabilitation of brain disorders and spinal cord injury; electrodiagnosis; musculoskeletal disorders and pain; pediatric, geriatric, cardiopulmonary, sports, cancer, cognitive, and robotic rehabilitation; neuromodulation; neuroimaging; orthotics and prosthetics; physical modalities; clinical trials; quality of life issues; and basic research, as well as other emerging fields in rehabilitation medicine.

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The manuscript guidelines for ARM are based on the “Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly work in Medical Journals” published by the International Committee of Medical Journal Editors (http://www.icmje.org), and instructions which are not mentioned in the present guidelines are referred to the guidelines stated in the Recommendations. There are no fees payable to submit in this journal.

1) ARTICLE TYPES

Manuscripts include original articles, review articles, brief reports, case reports, images in this issue, and letters to the editor.

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This form of publication represents original research articles reporting the results of basic and clinical investigations that are sufficiently well documented to be acceptable to critical readers.

(2) Review articles
The Editorial Board welcomes state-of-the-art review articles. The ARM strongly prefers systematic reviews of the literature. Invited review articles provide a comprehensive review of a subject of importance to clinicians and researchers and are commissioned by the editorial board to an invited expert in the field.

(3) Brief reports
These manuscripts are short but important reports to provide preliminary communications with less complete data sets than would be appropriate for original contributions that present novel and impactful clinical and basic research of a more preliminary nature.

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Case reports are considered for publication when at least one of the following criteria is met: (a) a rare condition is reported, (b)
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Critical comments are welcomed for providing alternative interpretations or views about articles published in ARM. Letters should be directly related to the published article on which it comments. Letters being considered for publication ordinarily will be sent to the authors, who will be given the opportunity to reply. Letters will be published at the discretion of the editors and are subject to abridgement and editing for style and content.

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All manuscripts must be written in clearly understandable English. Authors whose first language is not English are requested to have their manuscripts checked for grammatical and linguistic correctness before submission. Correct medical terminology should be used, and jargon should be avoided. Use of abbreviations should be minimized and restricted to those that are generally recognized. When using an abbreviated word, it should be spelled out in full on first usage in the manuscript followed by the abbreviation in parentheses. Numbers should be written in Arabic numerals, but must be spelled out when placed in the beginning of a sentence. Measurements should be reported using the metric system, and hematologic and biochemical markers should be reported in International System (SI) of Units. All units must be preceded by one space except percentage (%), temperature (°C), and degree (°).

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All manuscripts should be written with strict adherence to the research and publication ethics guidelines recommended by Council of Science Editors (http://www.councilscienceeditors.org/), International Committee of Medical Journal Editors (ICMJE, http://www.icmje.org/), World Association of Medical Editors (WAME, http://www.wame.org/), and the Korean Association of Medical Journal Editors (KAMJE, https://www.kamje.or.kr/en/main_en). For all studies involving human subjects, the principles embodied in the Declaration of Helsinki (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/) should be upheld, informed consent must be obtained from all participants, and must be approved by a recognized Institutional Review Board (IRB) or research ethics committee. The editor may request submission of copies of informed consents from human subjects in clinical studies or IRB approval documents. Experiments involving animals should comply with the NIH guidelines for the use of laboratory animals (https://www.nlm.nih.gov/services/research_report_guide.html) and/or be reviewed by an appropriate committee (e.g., Institutional Animal Care and Use Committee, IACUC) to ensure the ethical treatment of animals in research. Also, studies with pathogens requiring a high degree of biosafety should pass review of a relevant committee (e.g., Institutional Biosafety Committee, IBC). ARM will follow the guidelines by the Committee on Publication Ethics (COPE, http://publicationethics.org/) for settlement of any misconduct.

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ARM follows the recommendations by International Committee of Medical Journal Editors (ICMJE,http://www.icmje.org/) and and the Korean Association of Medical Journal Editors (KAMJE, https://www.kamje.or.kr/en/main_en). Authorship is credited to those who have direct involvement in the study and have made significant contributions to (a) substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (b) drafting the work or revising it critically for important intellectual content; AND (c) final approval of the version to be published; AND (d) agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved as recommended by ICMJE. The primary investigator is designated the first author of the study, unless contested by the other authors. The correspond-
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4) REGISTRATION OF CLINICAL TRIAL
Clinical trial defined as “any research project that prospectively assigns human subjects to intervention and comparison groups to study the cause-and-effect relationship between a medical intervention and a health outcome” is recommended to be registered in the primary registry to be prior publication. ARM recommend, as a condition of consideration for publication, registration in a public trials registry. ARM accepts the registration in any of the primary registries that participate in the WHO International Clinical Trials Portal (http://www.who.int/ictrp/en/), NIH Clinical Trials.gov (http://www.clinicaltrials.gov/), ISRCTN Resister (www.isrctn.org), ANZCTR (https://www.anzctr.org.au/), EudraCT Database (https://eudract.ema.europa.eu/), Clinical Trials Information System (https://ecuclinicaltrials.eu/), University Hospital Medical Information Network (www.umin.ac.jp/ctr/index/htm), EU Clinical Trials Register (https://www.clinicaltrialregister.eu/) or The Clinical Research Information Service (http://cris.nih.go.kr/). The clinical trial registration number will be published at the end of the abstract.

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6) PROCESS FOR HANDLING CASES REQUIRING CORRECTIONS, RETRACTIONS, AND EDITORIAL EXPRESSIONS OF CONCERN

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(1) Abstract
A structured abstract with the headings of Objective, Methods, Results, and Conclusion must succinctly describe the paper in 250 words or less. Use complete sentences and do not number the results. At the end of the abstract, list up to 5 relevant keywords which are in accordance to the Medical Subject Headings (MeSH).

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Clearly present the objective of the study and its relationship to earlier work in the field. A brief background to inform the readers of the relevance of the study may be necessary. However, avoid extensive review of the literature.

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Ensure correct use of the terms sex (when reporting biological factors) and gender (identity, psychosocial or cultural factors), and, unless inappropriate, report the sex and/or gender of study participants, the sex of animals or cells, and describe the methods used to determine sex and gender. If the study was done involving an exclusive population, for example in only one sex, authors should justify why, except in obvious cases (e.g., prostate cancer). Authors should define how they determined race or ethnicity and justify their relevance.

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Summarize and describe logically the significant findings and trends observed in the results using text, figures and tables. Avoid extensive repetition of contents of the tables and figures in the text.

In statistical expression, mean and standard deviation should be described as mean ± SD, and mean and standard error as mean ± SE. In general, p-values larger than 0.01 should be reported to two decimal places, those between 0.01 and 0.001 to three decimal places; p-values smaller than 0.001 should be reported as p < 0.001.

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Interpret the results in respect to the objective of the study, and describe differences with previous studies and significant findings which lead to the deduction of the conclusion. Refrain from excessive review of historic studies, textbook facts, or irrelevant references. Accentuate newly obtained observations from the study, and include significant limitations of the study.

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All sources of funding applicable to the study should be stated here explicitly. All original articles, editorials, reviews, and new technology articles must state funding sources for the study.

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Persons who have made contributions to the study, but who are not eligible for authorship can be named in this section. Their contribution must be specified, such as data collection, financial support, statistical analysis, or experimentation. The corresponding author must inform the named contributor of the acknowledgment, and acquire consent before manuscript submission.

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Legends should be submitted separately from the text, and each legend should be typed on separate pages. They should be written in full sentences to describe the content of the figure, and only the first letter of the legend should be capitalized. For lengthy legends continuing beyond one line, the left margin of the following lines should start at the same point as the first line. Any symbols, marks or abbreviations made in the figure must be explained in the legend. Figures containing histologic slides should be accompanied by legends explaining tissue origin, stain method, and microscopic amplification.

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Figures should be uploaded online as separate files and numbered in order of appearance in the text (e.g., Fig. 1). When a single numbered figure contains 2 or more figures, the figure should be numbered with an alphabet letter following the number (e.g., Fig. 1A, Fig. 1B). Indicate focus points in the figures with markers such as arrows and arrowheads, etc. Image files must be of resolutions higher than 300 dpi, and less than 3 MB, in JPEG, GIF, TIFF, or Microsoft PowerPoint format. A single numbered figure containing more 2 or more figures such as Fig. 1A and Fig. 1B should be uploaded as a single file.

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5) IMAGES IN THIS ISSUE
All images should be accompanied by a short description of the image and a brief and concise clinical review of the specific patient or clinical issue of no more than 500 words (excluding references) with references limited to 5. Image files must be of resolutions higher than 300 dpi for photographs, and 900 dpi for line art, waveforms, and graphs, in JPEG, GIF, TIFF, or Microsoft PowerPoint format. Images should make up a single figure, although they may contain more than one frame. The manuscript does not have an abstract.

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Letters should not have an abstract, tables, figures, and data supplements. Letters must be limited to roughly 500 words of text and no more than 5 references, 1 of which should be to the recent ARM article. Letters may have no more than 3 authors.

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When accepted for publication, the authors’ institutional affiliations should be inserted into the text of the final revised manuscript and uploaded to the online submission system. Files containing figures should be of the highest resolution (at least 300 dpi for color figures, and 900 dpi for line art and graphs) should be also be uploaded in JPEG, GIF, or TIFF format, and must be named according to the figure number (e.g., Fig. 1.jpg).

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☐ The Submission Application & Copyright Transfer Form is signed by the guarantor at original submission.

Abstract (applied to original articles, review articles, brief reports, and case reports)
☐ A structured abstract with the headings of Objective, Methods, Results, and Conclusion (A nonstructured abstract for case reports) must succinctly describe the paper.
☐ At the end of the abstract, relevant keywords are listed.

References
☐ All references have been checked for accuracy and completeness.
☐ Cite only references which are quoted in the text. Limit the number of references 40 for original articles, 10 for brief reports and case reports, and 5 for images in this issue and letters to the editor.
☐ Are numbered consecutively in the order they are cited in the text; all listed references have been cited in the text.
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