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Aims and Scope

Annals of Geriatric Medicine and Research (Ann Geriatr Med Res, AGMR) is a peer-reviewed journal that aims to introduce new knowledge related to geriatric medicine and to provide a forum for the analysis of gerontology, broadly defined. As a leading journal of geriatrics and gerontology in Korea, one of the fastest aging countries, AGMR offers future perspectives on policymaking for older adults, clinical and biological science in aging researches especially for Asian emerging countries. Original manuscripts relating to any aspect of geriatrics, including clinical research, aging-related basic research, and policy research related to senior health and welfare will be considered for publication. Professionals from a wide range of geriatric specialties, multidisciplinary areas, and related disciplines are encouraged to submit manuscripts for publication.

General Information

The official journal title has been *Annals of Geriatric Medicine and Research* since September 2016 which followed the Journal of the Korean Geriatrics Society (1997-2016, pISSN: 1229-2397, eISSN: 2288-1239). It is the official journal of the Korean Geriatrics Society (http://www.geriatrics.or.kr/eng/) and the Korean Society for Gerontology (http://www.korea-biogerontology.co.kr). It is published in English quarterly on the last days of March, June, September, and December. The journal publishes original research articles, case reports, reviews, special contributions, and commentaries. Review board consists of members in 7 different countries. Articles are welcome for submission from all over the world. The contents of this Journal are indexed in Web of Science, Scopus, PubMed, PubMed Central (PMC), EBSCO, DOAJ, Embase, KoreaMed, KoMCI, KCI, DOI/Crossref, and Google Scholar. It is accessible without barrier from Korea Citation Index (https://www.kci.go.kr) or National Library of Korea (http://nl.go.kr) in the event a journal is no longer published.

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Importance of Health Policy and Systems Research for Strengthening Rehabilitation in Health Systems: A Call to Action to Accelerate Progress

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In recent decades, the field of rehabilitation has undergone substantial development, growth, and acceptance. Rehabilitation addresses the impact of health conditions on a person's daily life by optimizing their functioning and reducing their disability experience. Rehabilitation expands the focus of health beyond preventative and curative care to ensure that people with health conditions can remain as independent as possible and participate in education, work, and meaningful life roles.[1)] A research definition of rehabilitation has been recently published.[2)] Scientific and clinical research has generated a body of knowledge that strongly supports the use of many rehabilitation interventions with positive outcomes in various populations and health conditions.

We also have a better understanding of the growing global needs, demands, and recognition of rehabilitation around the world. For example, it has been estimated that 2.41 billion people in the world could benefit from rehabilitation services. This means that at least one in every three persons in the world needs rehabilitation at some point during the course of their disease or injury.[3)] This figure has most likely increased because of the coronavirus disease 2019 (COVID-19) pandemic. The need for rehabilitation increased by 63% between 1990 and 2017 because of the aging population, the increasing prevalence of noncommunicable health conditions, and the shifting epidemiological profile in most countries.[3)] Finally, according to the 2022 global report on health equity for persons with disabilities, approximately 1.3 billion people, or 16% of the world's population, have moderate to severe levels of disability associated with underlying health conditions and impairments.[4)] Now more than ever before, it is crucial that rehabilitation is available and accessible to populations globally according to their needs. The important contribution of rehabilitation to functioning, including social and occupational participation, and the well-being of populations worldwide, can no longer be denied or delayed. Rehabilitation is critical for the attainment of the United Nations' Sustainable Development Goal 3, "Ensure healthy lives and promote well-being for all at all ages."[5)]

Notwithstanding the foregoing arguments, there continues to be a high unmet need for rehabilitation globally, with some low- and middle-income countries reporting unmet needs in up to 50% of people who could benefit from rehabilitation. Rehabilitation services are not accessible to many people worldwide.[6)] Many of those in need do not have access because of failure, at least partially, to effectively plan for rehabilitation services. Many nations and health systems have not implemented policy measures that recognize rehabilitation as an essential component of universal health coverage.[7,8)] Health policy, planning, and decision-making for rehabilitation often require more local evidence to adequately plan, finance, implement, and monitor quality rehabilitation services, including infrastructure and workforce, to make services accessible to those in need.[9)]

The field of health policy and systems research (HPSR) seeks to understand and improve how societies organize themselves in achieving collective health goals and how different actors interact in the policy and implementation processes to contribute to policy outcomes.[10,11)] By nature, it is interdisciplinary, a blend of medicine and health sciences, economics, sociology, anthropology, political science, law sciences, public health, and epidemiology that together draw a comprehensive picture of how health systems respond and adapt to health policies and how health policies can shape—and be shaped—by health systems and the broader determinants of health. The importance of HPSR for rehabilitation has been recently highlighted with robust data that need be considered and used by the health policy and systems community and leadership.[12)] HPSR for rehabilitation generates the evidence needed by policymakers to make appropriate decisions and to develop action plans to enhance the capacity of the health system to serve the population in need of rehabilitation services. For example, the evidence generated by

HPSR helps (1) establish priorities for delivering rehabilitation services; (2) evaluate the outcomes of various rehabilitation interventions in relation to the levels of care in the health system; (3) identify specific benefits to society justifying those decisions; and (4) strengthen health systems to increase access, quality, and provision of health services for rehabilitation.[13] Supported by the recent resolution on "Strengthening rehabilitation in health systems" endorsed by the World Health Assembly for the first time in the history of the World Health Organization,[14] it is time to leverage HPSR to support societal health goals as they apply to rehabilitation.

In 2022, the World Health Organization Rehabilitation Program established the World Rehabilitation Alliance (WRA)[15] to strengthen networks and partnerships that advocate for the integration of rehabilitation into health systems. The WRA is a World Health Organization-hosted global network of stakeholders whose mission and mandate are to support the implementation of the Rehabilitation 2030 Initiative[16] through advocacy activities. The WRA focuses on promoting rehabilitation as an essential health service service that is integral to Universal Health Coverage and to the realization of the United Nations' Sustainable Development Goal 3. The work of the WRA is divided into five workstreams: workforce, primary care, emergencies, external relations, and research. This research workstream is dedicated to the generation and routine use of HPSR evidence for planning and integrating rehabilitation into healthcare systems. The specific objectives of this study are to advocate for (1) the demand for and utilization of HPSR evidence for rehabilitation; (2) the widespread generation of high-quality HPSR evidence for rehabilitation; and (3) the publication, dissemination, and implementation of HPSR evidence for rehabilitation.

In this context, the coauthors of this editorial, on behalf of their respective academic journals, express their full support for the WRA's mission in general and for the specific objectives of the research workstream. In concrete terms, we commit that our journals, as much as possible, will implement one or more of the following actions: (1) invite researchers in the field of HPSR for rehabilitation to submit their manuscripts to our journals for peer review and publication; (2) create a special journal section, series, or designation dedicated to HPSR for rehabilitation; (3) appoint editorial board members with expertise in HPSR for rehabilitation; and (4) disseminate research articles among funding agencies and policymakers. These actions by our academic journals will help the WRA achieve its goal of strengthening rehabilitation services for all.

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CONFLICT OF INTEREST

The other authors claim no conflicts of interest.

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Geriatric Medicine in South Korea: A Stagnant Reality amidst an Aging Population

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In the face of an ever-increasing wave of an aging population, this paper provides an update on the current status of geriatric medicine in Korea, comparing it with global initiatives and suggesting future directions. Older adults require a multifaceted approach, addressing not only comorbidity management but also unmet complex medical needs, nutrition, and exercise to prevent functional decline. In this regard, the World Health Organization's Integrated Care for Older People guidelines underscore the importance of patient-centered primary care in preventing a decline in intrinsic capacity. Despite these societal needs and the ongoing aging process, the healthcare system in Korea has yet to show significant movement or a shift toward geriatric medicine, further complicated by the absence of a primary care system. We further explore global efforts in establishing age-integrative patient-centered medical systems in Singapore, Australia, Canada, the United Kingdom, and Japan. Additionally, we review the unmet needs and social issues that Korean society is currently facing, and local efforts by both government and a private tertiary hospital in Korea. In conclusion, considering the current situation, we propose that the framework of geriatric medicine should form the foundation of the future healthcare system.

Key Words: Geriatrics, Geroscience

INTRODUCTION

Despite the relentless march of time and the ever-increasing wave of an aging population, South Korea's commitment to geriatric medicine remains disappointingly static. As we step into 2024, a sobering reflection on the past 5 years reveals a concerning paradox: while the number of older adults in need of specialized or complex care has grown, the systemic support for geriatric medicine has not kept pace. In this article, we update the widening unfilled gap in establishing geriatric medicine in Korea, from the 2018 article calling the Korean healthcare system to urgently adopt the concept of geriatrics.[1)]

THE UNCHANGING FACE OF GERIATRIC SUPPORT

Over the last half-decade, the promise of institutional support for geriatric medicine in Korea has largely remained unfulfilled. The healthcare system continues to grapple with the same challenges it faced in 2018, with no significant policy advancements or shifts in funding to bolster this critical area.[2)] This stagnation is not just a missed opportunity but a growing liability as the older population burgeons, bringing with it complex health needs that demand specialized attention. Currently, while there is discussion about the lack of essential healthcare services such as pediatrics, obstetrics, and emergency care, paradoxically, the need for primary care and geriatric medicine, which are considered fundamental in healthcare systems worldwide, is conspicuously absent from policy discussions in Korea. This perspective by policymakers fails to recognize the critical importance of these areas, particularly in the context of an aging society that requires dedicated attention to the unique health challenges faced by older adults.

Geriatric medicine fundamentally recognizes the diversity and complexity in the health status of older adults, acknowledging the significant variability in disease burden and physical capabilities within this demographic. This field draws parallels with pediatrics by emphasizing the unique physiological differences in its patient group, understanding that older individuals are not merely adults of an advanced age.[3] Geriatricians consider the often limited applicability of clinical trial results, which are typically based on younger populations,[4] to their multifaceted patient base suffering from multiple chronic conditions and physical impairments. This approach necessitates a comprehensive, patient-centered strategy that encompasses a variety of healthcare settings, from acute hospital care to long-term community-based assistance.[5] In managing these diverse health needs, geriatric care often involves collaboration across medical specialties and diverse healthcare professionals. Through a holistic and individualized geriatric approach, tailored treatment plans can be developed that cater to the specific requirements of each patient, ultimately providing optimal, proactive, and multifaceted interventions that enhance and preserve intrinsic capacity.

CONTRASTING WITH WHO'S ICOPE GUIDELINES: THE UNSETTLED STATE OF PRIMARY CARE IN KOREA

The World Health Organization's Integrated Care for Older People (ICOPE) guidelines urge primary healthcare systems to uptake the basic geriatric concepts, proactively identify and manage geriatric syndromes and frailty, emphasizing the need to prevent the decline of intrinsic capacity in older adults. The guidelines also recognize primary entrance points for community-based interventions and support. These guidelines represent a global consensus on the importance of primary care in the holistic management of aging populations, focusing on prevention and early intervention.[5]

However, in stark contrast to these international standards, South Korea's primary care system remains in a nascent and unsettled state. Despite the urgency highlighted by the World Health Organization, the Korean healthcare framework has not yet established a robust primary care system that can effectively address the nuances of geriatric health. The underdevelopment of primary care in Korea has far-reaching consequences. Without a strong primary care foundation, the early detection and management of geriatric conditions are significantly hampered. Due to the lack of basic geriatric medicine services, even fundamental geriatric syndromes in the community are often addressed through fragmented care across multiple specialized departments. This fragmentation often leads to a prescribing cascade, where the accumulation of various medications can inadvertently result in further functional decline among the older populations.[6] This situation not only undermines the health and wellbeing of older adults but also leads to increased healthcare costs and resource utilization. The current gap is particularly alarming given the rapid aging of the Korean population and the increasing prevalence of geriatric syndromes and frailty among older adults.

GLOBAL PERSPECTIVES

In stark contrast to Korea's static approach, other nations have made strides in geriatric care, adapting to the needs of their aging populations with innovative policies and practices.

Singapore, in response to its rapidly aging population and the accompanying healthcare challenges, has undertaken systemic reforms to create a more integrated, patient-centric, and health-centered healthcare system.[7-9] Recognizing the limitations of traditional, fragmented healthcare models, Singapore reorganized its healthcare into Regional Health Systems (RHSs), incorporating acute general hospitals, community hospitals, nursing homes, and other care providers. This reorganization aims to provide seamless, holistic care across different stages of a patient's healthcare journey, from diagnosis to post-discharge follow-up. Special emphasis is placed on community initiatives, such as Wellness Kampungs and Dementia-Friendly Communities, to support aging-in-place and enhance the quality of life for older adults and their caregivers. Initiatives like Project Care and Geriatric Surgical Services focus on reducing unnecessary hospital admissions and improving care for older patients. Transitional care services and Ageing-in-Place Community Care Teams ensure continuous support post-discharge, optimizing the use of hospital resources and reducing readmissions. Overall, these efforts exemplify a shift towards a sustainable, evidence-based approach in healthcare delivery, prioritizing function and intrinsic capacity over disease-focused care.[7]

In Australia, the aged care system had faced challenges due to fragmentation and the impact of government policies promoting deregulation and market forces in aged care. This approach came under scrutiny in the Royal Commission into Aged Care Quality and Safety, which documented widespread substandard care across various levels.[10] Despite these policy challenges, there has been a positive development in the field of geriatric medicine in Australia. Geriatricians have been instrumental in expanding medical services and interventions targeting specific issues such as dementia, falls, polypharmacy, and orthogeriatrics. The number of academic geriatricians and other aged care health professionals is on the rise. The training for specialist geriatricians now includes a significant research component, reflecting a commitment to advancing the field through both practical application and academic inquiry.[10]

Since its accreditation by the Royal College in 1977, Geriatric

Medicine in Canada has evolved, encompassing a range of clinical, educational, and research activities.[11] This growth has spurred public and governmental awareness about the need for specialized geriatric services. Canadian geriatricians have become influential in healthcare leadership, contributing to the development of age-friendly hospitals and the implementation of Acute Care for the Elders (ACE) units. These units focus on providing patient-centered care and addressing the unique needs of a vulnerable older population.[11]

In the United Kingdom, geriatrics is recognized as a distinct medical specialty, akin to pediatrics, with approximately 12% of physicians specializing in geriatric care. Geriatricians address both acute and chronic health issues, as well as manage geriatric syndromes and disabilities. The foundation of geriatric clinics is a patient-centered, holistic approach, and geriatricians provide continuous, personalized care not only in clinics but also in settings such as the emergency department, in-hospitals, and hospice care.[12]

In Japan, starting in 2005, the Community-based Integrated Care System was established.[13-15] It consists of five key components: housing, medical care, long-term care, preventive care, and daily living support. In this system, the framework of geriatric medicine is embedded to provide person-centered healthcare and welfare service. At the center of this system are patients and their families, with coordination facilitated by a manager. These five elements work together in harmony. In terms of medical care, there is a comprehensive range from acute care hospitals to chronic hospitals, including rehabilitation facilities and primary care services. A primary goal of this system is to prevent long-term care needs and functional decline.

UNMET NEEDS

Each country possesses its own age-integrated patient-centered system that encompasses not only medical care but also social support and nursing care. These global examples offer valuable lessons that Korea could draw from, ranging from integrated care models to improved training and support for geriatric specialists. The reluctance to embrace such strategies in Korea is not just a lack of innovation but a disregard for global best practices that could reshape the landscape of geriatric care. There are several needs and issues that Korean society is currently facing.

First, healthcare expenses are escalating rapidly. According to Health Statistics 2023 from the Organization for Economic Co-operation and Development (OECD), the expenditure on health compared as a percentage of gross domestic product (GDP) in 2022 was 9.7%, which turns higher than OECD mean (9.2%), and the increasing rate is notably faster compared with other OECD countries (Fig. 1). Analyzing Fig. 1, with the current Korean medical system and the changing population structure, the surge in the social burden of medical expenses is inevitable and necessitating radical changes in the medical system.

Second, there is lack of a care transition system encompassing transitions within tertiary medical institutions, local healthcare facilities, and long-term care institutions.[16] In such a system, while the treatment of diseases may be possible, preventing functional decline and promoting functional recovery may not be achievable. Care transitions encompass all shifts within healthcare settings, involving not only the shifting location of care but also patient-centered, multidisciplinary medical services such as communication, home visits, primary care, and follow-up.[16] In Korea, many services are absent, and if they exist, the systems are fragmented. For example, Korean Long-Term Care Insurance (LTCI) only covers existing care needs without emphasizing prevention and medical coordination. Even though frail older adults are prone to hospitalization-associated disability,[17-19] LTCI does not address caregiving issues in post-acute care. Consequently, Korean systems fail to prevent the progression from frailty to disability, leading to a continu-

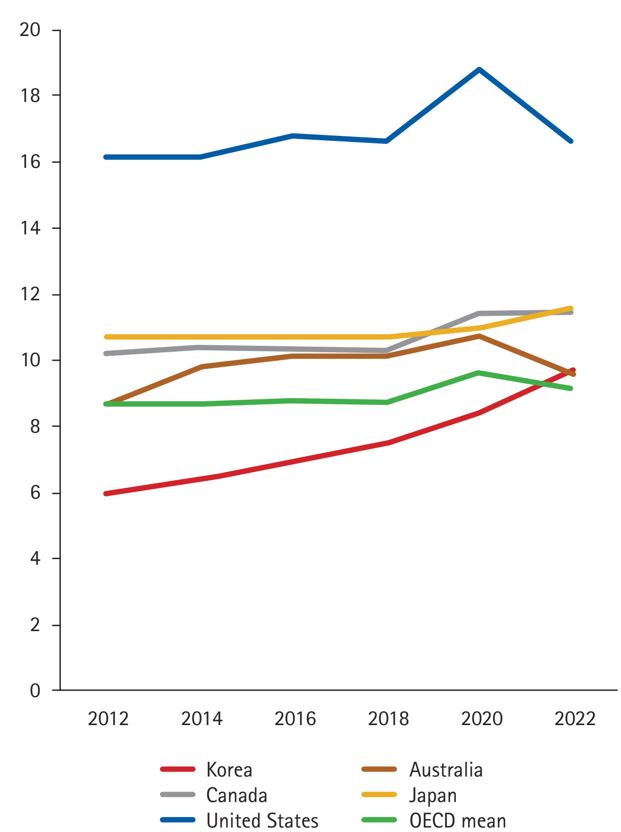

Fig. 1. Expenditure on health compared to gross domestic product (GDP) of OECD countries (percentage). Source: OECD Stats (December 2023), Health Expenditure and Financing, https://stats.oecd.org/Index.aspx?DataSetCode=SHA.

ous increase in caregiving costs in Korea.[20]

Third, with increasing number of older adults and disease-oriented healthcare system, multimorbidity and polypharmacy are inevitable.[21] Moreover, disease-specific medical practices are prone to prescription cascade.[22] Research based on 2018 National Health Insurance Data indicates that 35.9% of older adults aged 65 years or older are taking five or more medications. Among them, 44.7% have potential inappropriate medications, and 30.6% have duplicate prescriptions of the same ingredient on the same date from different institutions.[23] Furthermore, older adults with more prescription had worse outcomes including mortality, adverse medication effects, increased medical expenses, and lower quality of life.[23-25] Addressing these issues requires a patient-centered comprehensive geriatric approach that considers the all medical histories and unmet medical needs and provides appropriate medical interventions. However, in the Korean medical system, lacking an appropriate reimbursement system, such practices are challenging to implement. Unless there is fundamental shift from diagnostic test or procedure focused reimbursement system, it appears challenging the so-called "3-minute medical consultations" to improve in the future.

LOCAL EFFORTS

One of the local efforts may include the example of a tertiary hospital, which achieved committed to care excellence designation of the age-friendly health system in Korea, as demonstrated in a recent studies.[26,27] This example highlighted the effectiveness of the Clinical Frailty Scale (CFS), which evaluates the functional status of patients within 24 hours of acute hospital admission, in predicting geriatric outcomes like falls, pressure ulcers, and delirium, as well as general hospital outcomes including death, emergency visits, and readmissions. The tertiary has been integrating the at-point CFS into its electronic health records.[27] This integration is part of their initiative to adopt the 4M framework (matter, mentation, medication, and mobility) in developing an acute care pathway for older adults. This approach is aimed at providing efficient, person-centered geriatric interventions within their large-scale hospital environment. However, this system operates without any government support or payment structure. In Korea, there is a pressing need to integrate an age-friendly healthcare system that spans downstream service provision, striving to harmonize the integration of disease management, functional considerations, and caregiving demands.

The polypharmacy management project in Korea, initiated in 2018 by the National Health Insurance Service, is designed to manage the use of multiple medications, particularly in the aging population. The purpose is to review and organize these medications to prevent side effects associated with polypharmacy. Its hospital mode, initiated in 2020, has seen substantial growth. Initially starting with just seven hospitals, the initiative has grown about sevenfold in four years, with 36 hospitals participating last year and increasing to 48 this year. The project targets inpatients and outpatients for multiple drug management services. The rapid expansion of participating institutions is attributed to both online and offline regional meetings aimed at promoting the project and encouraging participation from local medical institutions. The project is organized into two models: the inpatient/outpatient model and the outpatient model, with each participating hospital potentially operating different models. The core service constitutes a multidisciplinary team of pharmacists, doctors, and nurses managing polypharmacy in chronic disease patients.

Korea's Primary Healthcare Home Visit Fee Pilot Project, launched in December 2019, has been extended ever since, as 526 medical institutions and 696 doctors have registered for the project, with actual claims made by 142 institutions and 185 doctors in 2023. Despite the project's growth, the participation rate among all medical institutions remains low at 0.4%, and the patient utilization rate is only 1.9% when calculated to the estimated adult population who have difficulty moving and could benefit from such services.[28] Despite these individual initiatives, there remains a fundamental lack in the foundation of primary healthcare providing geriatric medical services. This gap highlights the need for a more systemic approach to address the healthcare requirements of the aging population.

POTENTIAL SOLUTIONS

Several potential solutions can contribute to the integration of a geriatric perspective into our society. First, the establishment of geriatric specialists and the implementation of a comprehensive training system are imperative. This training should extend not only to physicians but also to paramedics, social workers, and policymakers, fostering an understanding of geriatric concepts. The need for manpower extends beyond geriatric clinics, encompassing policymaking and evidence generation. An initial step towards a robust geriatric training system would be the official recognition of geriatrics as a subspecialty or specialty. Second, there is a necessity to reform the medical delivery system and reimbursement structures to effectively deliver ICOPE. The current system, which often lacks a primary care focus, falls short in preventing the functional decline of older adults. Third, an organized care transition system from tertiary hospitals to local clinics or long-term care facilities should be promoted and incentivized through appropriate reimbursement. Lastly, a paradigm shift is needed where frailty and intrinsic capacity take center stage in the care system, superseding the reliance on chronological age and specific diseases. This holistic approach ensures that the care system addresses the unique needs of older adults, fostering a healthier and more resilient aging population.

LOOKING AHEAD: A CALL FOR URGENT REFORM

This update serves as a clarion call for immediate action. Policymakers must recognize the importance of geriatric medicine, aligning it with the country's demographic reality. This call extends to increased funding, policy reform, and a public awareness campaign to elevate the importance of geriatric care in the national consciousness. In light of the systemic inertia, exploring alternative solutions becomes imperative. Community-driven initiatives, private sector innovations, and technology-driven approaches could offer some respite. However, without substantial changes, the future of geriatric care in Korea appears grim. The increasing older population, coupled with inadequate healthcare support, forecasts a crisis that could strain the healthcare system to its breaking point. The need for urgent reform is clear: Korea must embrace the concept of geriatric medicine not just as a specialty but as a foundational pillar of its healthcare system, adapting to the realities of its aging society.

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CONFLICT OF INTEREST

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Functional Status in Older Adults following Hospitalization for COVID-19: A Cohort Study

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Background: Coronavirus disease 2019 (COVID-19) can cause multiple acute complications. This study evaluated the long-term functional status of older patients hospitalized for acute COVID-19. **Methods:** We analyzed data from a multicenter ambispective cohort study on patients aged >60 years who were hospitalized for COVID-19 at two tertiary care hospitals in Argentina. The participants were contacted by telephone between November 2021 and September 2022 to collect data on their functional status. Ordinal logistic regression was used to identify factors associated with functional limitations after discharge. **Results:** Among the 374 included patients, 205 (55%) showed functional limitations, including 58 (28%) who died during follow-up. The factors independently associated with functional limitations were low baseline functional status (odds ratio [OR]=9.19; 95% confidence interval [CI], 3.35–25.17) and admission to the intensive care unit (OR=4.41; 95% CI, 2.28–8.53). Men had lower odds of functional impairment (OR=0.55; 95% CI, 0.35–0.86). **Conclusion:** Older patients had high mortality rates and poor functional status at 2 years post-discharge for COVID-19. Several factors at the time of discharge were associated with a higher risk of functional limitations and can be used to identify patients' long-term needs for support and rehabilitation services.

Key Words: Aged, Hospitalization, Post-acute COVID-19 syndrome, Physical functional performance

INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in December 2019 in Wuhan, China.[1)] It subsequently spread rapidly worldwide and was declared a pandemic by the World Health Organization in 2020. COVID-19 has high infection rates, significant morbidity, and mortality rates.[2)] Although the prevalence and mechanisms are not yet fully understood, several studies have reported persistent symptoms following acute COVID-19. This entity involves multiple systems and has been labeled as "long COVID-19 syndrome" or "post-COVID-19 syndrome." The possible contributing factors include residual organ damage, persistent systemic inflammation, effects of hospitalization, and associated comorbidities.[3)] Because of the number of individuals affected and the substantial impact on well-being, the short- and long-term sequelae of COVID-19 have emerged as major public health concerns.[4,5)]

The impact of COVID-19 on physical and mental health has been documented.[6,7)] Studies have described functional status limitations after COVID-19 among patients with mild-to-severe acute disease, with more frequent and severe functional limitations after hospitalization. Huang et al.[8-10)] showed that up to 47% of patients requiring intensive care unit (ICU) admission experienced functional limitations 6 months after discharge, compared to 25% to 30% of other hospitalized patients. However, little is known about the rates of functional impairment in older patients hospitalized for COVID-19, a group at a higher risk of poor outcomes. Data from this vulnerable patient group are critical for planning appropriate rehabilitation care after discharge.

This study described the frequency and risk factors for functional limitations in older adults hospitalized for acute COVID-19 at two large tertiary care medical centers in Argentina.

MATERIALS AND METHODS

Study Design and Participants

We used data from a multicenter, ambispective cohort study conducted at Dr. César Milstein Hospital, a university hospital located in Buenos Aires City, Argentina, managed by the National Institute of Social Services for Retirees and Pensioners (INSSJP/PAMI), and the Regional Hospital Dr. Víctor Sanguinetti, a public hospital in the city of Chubut, Argentina, and associated with the National University of Patagonia San Juan Bosco. This study was approved by the Institutional Review Boards of IRB Hospital Dr. César Milstein (No. 5265) and Hospital Dr. Víctor Sanguinetti (No. 03/2023). Also, this study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[11] Eligible participants were adults > 60 years of age who survived hospitalization for acute COVID-19 at one of the participating hospitals between April 2020 and March 2022. SARS-CoV-2-19 infection was determined based on a positive polymerase chain reaction (PCR) or rapid antigen test. We excluded patients who could not be contacted by phone for follow-up and those who did not agree to participate in the study.

Procedures

The participants were contacted by phone between November 2021 and September 2022 by trained study personnel, who conducted interviews to collect data on the study variables using a standardized questionnaire. Additional information was obtained from an institutional registry containing the sociodemographic and clinical characteristics of all patients admitted for COVID-19 to Víctor Sanguinetti Hospital. We also reviewed the medical records of patients admitted to both hospitals to complement the survey data. Finally, we reviewed the INSSJP/PAMI registry to identify patients who died after discharge and extracted data on the date of death.

The sociodemographic data included age, sex, and years of education (elementary/middle school, high school, college, or doctoral degree). We obtained information from medical records regarding comorbidities at admission, including a history of cardiovascular disease, cerebrovascular disease, chronic obstructive pulmonary disease (COPD), asthma, diabetes (DM), and cancer.

We used the Katz Index to characterize the patients' ability to independently conduct activities of daily living before admission, which was collected by self-report at the time of the follow-up call. The instrument evaluates six basic functions of daily living (bathing, dressing, feeding, toilet use, continence, and mobility) and summarizes the patient's status into eight categories, from total independence (A) to high dependence (H; loss of all functions). Hospitalization-related variables included ICU admission and length of hospital stay. The disposition locations (home vs. nursing home) at discharge were collected from medical records.

Outcomes

The primary outcome was functional status post-discharge, which was assessed at the time of the follow-up call using the Latin-American version of the Manual for the Post-COVID-19 Functional Status Scale.[12] This validated scale classifies functional status into the following categories: no functional limitation (ability to live alone and perform daily activities without help and without experiencing symptoms); minimal functional limitation (ability to perform daily activities but with symptoms); mild functional limitation (need to reduce or avoid certain daily activities because of symptoms); moderate limitation (ability to perform certain daily activities but loss of ability to perform others); severe functional limitation (inability to live independently and perform daily activities); and death. For the analysis, we grouped the minimal, mild, moderate, and severe categories to create a four-level variable indicating no limitation, mild limitation, moderate limitation, or death.

Statistical Analysis

The baseline characteristics of the study participants according to the four categories of functional status limitation were compared using analysis of variance (ANOVA), Kruskal–Wallis test, or chi-square test, as appropriate. The distribution of functional status impairments in the first year and > 1-year post-discharge was calculated using descriptive statistics.

We used ordinal logistic regression to assess the independent associations of age, sex, education, history of cardiovascular disease, COPD, asthma, DM, baseline Katz index, ICU admission, length of stay, and discharge disposition with functional status. Regarding the age variable, we used a range between 60 and 70 years old as a reference value. For the multivariate analysis, we collapsed the Katz Index into Katz A as the reference value (no impairment in performing daily living activities), Katz B (mild impairment), and Katz C or worse (major impairment). The model was also adjusted for the time from discharge to the follow-up call to control for potential changes in functional status over time.

Power calculations showed that with a sample of approximately 370 patients, the study had >80% power to identify predictors, with a prevalence of 30% and a 15% absolute difference in functional status.

The statistical analyses were conducted using Stata version 13 (Stata Corporation, College Station, TX, USA) with two-tailed p-values and a significance level of 0.05.

RESULTS

From November 2021 to September 2022, 623 patients were admitted for COVID-19 at Dr. César Milstein Hospital and were eligible for inclusion. Of these, 192 (30%) were excluded due to in-hospital death, and 89 (14%) were excluded due to age <60 years (3%), inability to be contacted (10%), or refusal to participate (1%), leaving a cohort of 342 patients. We also included 32 patients admitted to Dr. Víctor Sanguinetti Hospital, resulting in a final cohort of 374 patients (Fig. 1). The median time from discharge to follow-up was 425 days (interquartile range [IQR], 322–495 days). Interviews were conducted during the first year and between 12 and 24 months post-discharge in 133 (35%) and 240 (64%) participants, respectively.

Baseline characteristics and hospitalization-related variables according to functional status are shown in Table 1. Patients with worse functional status or those who died after discharge were older ($p<0.001$), more likely to be female ($p=0.009$), and less likely to have completed elementary/middle school ($p=0.02$). The two most prevalent comorbidities among the study participants were hypertension (68.1%) and DM (71.4%). Heart failure, chronic kidney disease, dementia, and cancer were more common in patients who died after discharge ($p=0.04$, $p=0.02$, $p<0.001$, and $p=0.005$, respectively). The levels of functional status at baseline differed significantly across the groups, with more severe impairment associated with worse post-discharge outcomes ($p<0.001$). The median overall length of stay was 12 days (IQR, 8–21 days), with longer stays in older patients with worse functional status post-discharge ($p<0.001$). ICU admission during hospitalization ($p=0.003$) and discharge to a rehabilitation or nursing home facility ($p<0.001$) were associated with poor functional outcomes post-discharge (Table 2).

Among 136 patients (36%) with 1-year follow-up data, 29.4%, 13.2%, and 22.7% reported no, mild, and moderate/severe limitations, respectively, while 35.3% of the patients had died. Among the 237 patients followed up at 2 years post-discharge, 53.5%, 16.4%, and 25.7%, reported no, mild, and moderate/severe limitations, respectively, while 4.2% had died (Fig. 2).

The factors significantly associated with functional limitations post-discharge in adjusted analyses were older age (odds ratio [OR]=1.86; 95% confidence interval [CI], 1.14–3.03), worse baseline functional status—Katz B (OR=9.19; 95% CI, 3.35–25.17), Katz C or worse (OR=13.30; 95% CI, 6.02–29.36)—and ICU admission (OR=4.41; 95% CI, 2.28–8.53). Conversely, male sex was associated with lower odds of functional limitations (OR=0.55; 95% CI, 0.35–0.86). Additionally, the model showed a significant association between the time since discharge and functional status, e.g., for every 6-month period after discharge, the odds of an increase in the functional limitation scale decreased by 0.50 (95% CI, 0.37–0.66).

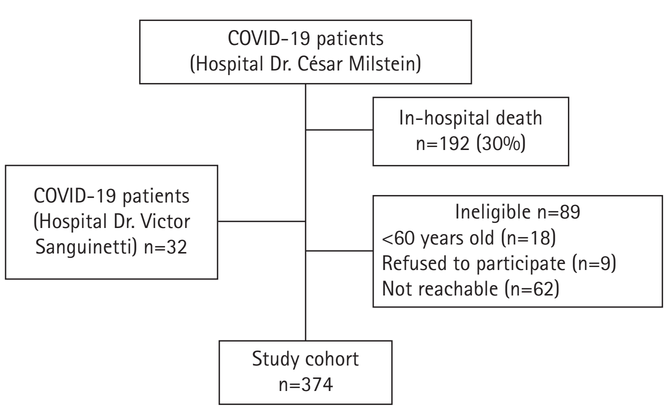

Fig. 1. Consort diagram.

DISCUSSION

COVID-19 is associated with multiple long-term conditions that can substantially and negatively affect patient health and quality of life. In this study, we observed high levels of functional limitations up to 2 years post-discharge from hospitalization among older adults with COVID-19. Additionally, we identified several predictors of poor functional status and mortality that could help identify patients who may require home support and/or rehabilitation services after discharge. This information can guide discharge planning and inform the development of interventions to support the health and maintain the independence of older adults requiring hospitalization for acute COVID-19.

Previous studies described the functional outcomes of patients admitted to hospital for COVID-19. A cohort study of 318 older patients who survived hospitalization for COVID-19 showed a 36% prevalence of functional limitations 3 months after discharge.[13] Consistent with our findings, Battistela et al.[14] found that 71% of COVID-19 survivors reported limitations in their daily activities 11 months post-discharge from the hospital. In addition, a Chinese ambispective cohort study including data from

Table 1. Sociodemographic and clinical baseline characteristics of study population

Variable	Total (n = 374)	Functional limitation				p-value
		No limitation (n = 167)	Mild/moderate (n = 57)	Severe (n = 91)	Death (n = 58)	
Age (y)	73 (68–79)	72 (67–77)	71 (67–75)	75 (70–80)	77 (72–82)	< 0.001
60–70	136 (36.46)	79 (47.31)	24 (42.11)	23 (25.27)	10 (17.24)	
71–80	171 (45.84)	66 (39.52)	27 (47.37)	49 (53.85)	29 (50.00)	
81–90	57 (15.28)	21 (12.57)	4 (7.02)	15 (16.48)	17 (29.31)	
> 90	9 (2.41)	1 (0.60)	2 (3.51)	4 (4.40)	2 (3.45)	
Sex						
Female	212 (56.8)	80 (47.9)	37 (64.9)	62 (68.1)	33 (56.9)	0.009
Male	161 (43.2)	87 (52.1)	20 (35.1)	29 (31.9)	25 (43.1)	
Education						
Primary or lower	198 (57.3)	84 (50.9)	26 (49.1)	65 (74.7)	23 (57.5)	0.002
High school or superior	147 (42.6)	81 (49.1)	27 (50.9)	22 (25.3)	17 (42.5)	
Hypertension	254 (68.1)	104 (62.3)	38 (66.7)	68 (74.7)	44 (75.9)	0.11
Diabetes	267 (71.4)	47 (28.1)	18 (31.6)	26 (28.6)	15 (25.9)	0.92
COPD/asthma	53 (14.2)	22 (13.2)	6 (10.5)	14 (15.4)	10 (17.2)	0.72
Coronary heart disease	33 (8.8)	13 (7.8)	4 (7.0)	7 (7.7)	9 (15.5)	0.28
Heart failure	26 (7.0)	6 (3.6)	3 (5.3)	9 (9.9)	8 (13.8)	0.04
Cerebrovascular desease	10 (2.7)	2 (1.2)	2 (3.5)	3 (3.3)	3 (5.2)	0.38
Dementia	25 (6.7)	1 (0.6)	0 (0)	16 (17.6)	8 (13.8)	< 0.001
Chronic kidney disease	17 (4.6)	5 (3.0)	1 (1.8)	4 (4.4)	7 (12.1)	0.02
Solid cancer	0 (0)	11 (6.6)	4 (7.0)	3 (3.3)	11 (19.0)	0.005
Hematologic cncer	11 (2.9)	3 (1.8)	1 (1.8)	2 (2.2)	5 (8.6)	0.05
Baseline Katz Index						
A	300 (83.5)	166 (99.4)	54 (94.7)	60 (65.9)	20 (45.5)	< 0.001
B	25 (6.9)	1 (0.6)	1 (1.7)	8 (8.7)	15 (34.1)	
C or worse	34 (9.5)	0 (0)	2 (3.5)	23 (25.2)	9 (20.4)	
Length of stay (day)	12 (8–21)	10 (7–16)	11 (7–16)	14 (9–28)	20 (11–37)	< 0.001
ICU requirement	42 (11.2)	8 (4.8)	7 (12.3)	18 (19.8)	8 (13.8)	0.003
Discharge disposition						
Home	326 (87.4)	159 (95.2)	53 (93.0)	66 (73.3)	48 (82.8)	< 0.001
Other	47 (12.6)	8 (4.8)	4 (7.0)	24 (26.7)	10 (17.2)	

Values are presented as median (interquartile range) or number (%).
COPD, chronic obstructive pulmonary disease; ICU, intensive care unit.

2,469 survivors of COVID-19 hospitalization, also showed worse functional status rates compared to healthy controls 2 years after discharge.[15)]

In this study, we observed that male sex was associated with a lower likelihood of functional limitations. Likewise, worse baseline functionality, older age, and ICU admission were associated with poorer functional status. These findings are consistent with those of previous studies.[16-19)]

Moreover, our analyses showed that admission was associated with increased functional limitations and/or mortality after discharge. Previous studies described functional impairments following ICU admission owing to COVID-19 and other critical illnesses. Cavalleri et al.[20)] assessed functional status 1 year after hospital discharge and found that approximately 35% of critically ill patients experienced functional limitations without significant differences between those admitted as a consequence of COVID-19 and other conditions.

High rates of functional limitation after hospitalization have also been reported in patients not requiring critical care. A pre-pandemic prospective cohort of 230 older adults discharged from Milstein Hospital reported a 68% rate of short-term functional limitations.[21)] Long-term functional limitations after a non-COVID-19 acute illness requiring hospitalization were also reported in 27% of 369 patients in a Spanish cohort.[22)] These findings suggest that the high rates of long-term functional disability observed in our cohort may not solely be due to COVID-19, and may also represent the impact of acute disease, hospital-related complications, baseline limitations in functional status, comorbidities, and the well-described "post-ICU syndrome."[23,24)]

We observed a 1-year post-discharge mortality rate of 12.8% and

Table 2. Adjusted associations between baseline characteristics and functional status after discharge

Characteristic	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Sex, male	0.61 (0.41–0.89)	0.012	0.55 (0.35–0.86)	0.009
Age (y)				
60–70	Ref.	NA	Ref.	NA
71–80	2.31 (1.50–3.54)	0.000	1.86 (1.14–3.03)	0.012
81–90	3.50 (1.93–6.36)	0.000	1.75 (0.83–3.66)	0.138
> 90	4.90 (1.56–15.45)	0.007	2.79 (0.77–10.12)	0.118
Education, > elementary school	0.58 (0.39–0.87)	0.009	0.75 (0.48–1.16)	0.195
Katz Index				
Level A	Ref.	NA	Ref.	NA
Level B	29.84 (12.30–72.39)	0.000	9.19 (3.36–25.17)	0.000
Level C or worse	11.70 (5.95–23.00)	0.000	13.30 (6.02–29.36)	0.000
Hypertension	1.65 (1.10–2.48)	0.016	1.30 (0.81–2.08)	0.278
Diabetes	0.96 (0.64–1.45)	0.860	0.93 (0.56–1.53)	0.768
COPD/asthma	1.24 (0.72–2.13)	0.430	1.36 (0.72–2.56)	0.344
Intensive care admission	2.43 (1.39–4.26)	0.002	4.41 (2.28–8.53)	0.000
Time from discharge, per 6 months	0.42 (0.34–0.54)	0.000	0.50 (0.37–0.66)	0.000

COPD, chronic obstructive pulmonary disease; OR, odds ratio; CI, confidence interval; NA, not applicable.

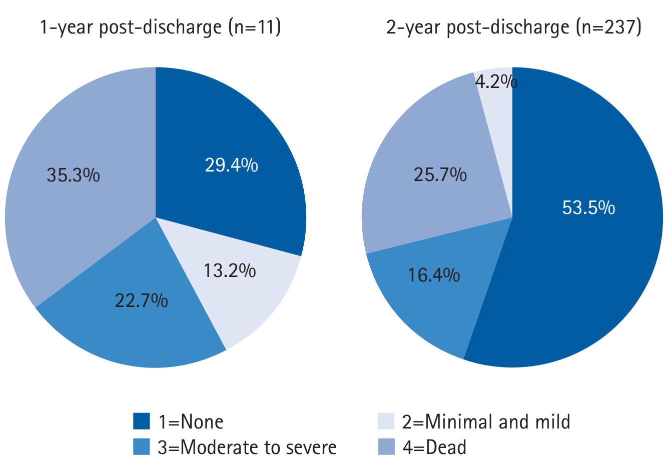

Fig. 2. Functional status distribution among older patients discharge following COVID-19 hospitalization. Most deaths occurred during the first year post-discharge. More than 50% of patients had no functional limitations >1-year post-discharge.

a cumulative mortality at 2 years of 16%. Other studies on older patients with acute COVID-19 showed heterogeneous long-term survival outcomes, ranging from < 4% to 13%.[25-28] High mortality rates (up to 20% or 33%) because of non-cardiovascular acute illnesses were observed in older adults discharged from hospitals.[21,22] Similarly, cohorts of survivors of critical illness associated with respiratory failure in the pre-COVID-19 era reported mortality rates of 17% and 38% at 6 months and 2 years, respectively.[29] These differences may be related to the baseline characteristics and pre-admission functional statuses of the populations reported in these studies.

This study had several strengths and limitations that should be considered when interpreting the results. The strengths of this study include the use of a well-validated scale to measure functional status, which was specifically designed to assess patients post-COVID-19. Additionally, we followed the participants for up to 2 years post-discharge to assess the long-term outcomes. The limitations of this study included the limited study sites. While we included patients from two large medical centers, most participants were admitted to Dr. César Milstein Hospital, which potentially limits the generalizability of our results. However, Dr. César Milstein is a major medical center in Buenos Aires that serves a large population of publicly insured inner-city older adults. Additionally, we collected self-reported data (e.g., pre-admission functional status) several months post-discharge, which may have been influenced by recall bias. However, several variables were obtained from medical records or institutional registries at the time of admission. Finally, we did not include a control group of patients without COVID-19. Thus, we could not explore whether the observed limitations in functional status were specifically related to COVID-19 or were generally associated with the need for hospitalization or ICU stay.

In conclusion, the results of our study showed relatively high rates of early severe functional limitations and mortality among older adults post-discharge for COVID-19. Our findings can help identify patients at high risk of poor functional outcomes following discharge and plan home support interventions to assist the needs of these patients. Early recognition and rehabilitation programs may be required to effectively prevent or manage the long-term complications of severe COVID-19 in older adults.

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CONFLICT OF INTEREST
The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS
Conceptualization, MPI, MG, DC; Data curation, MPI, ELA, JAVB; Investigation, MPI, ELA, JAVB; Methodology, MPI, DC; Project administration, AZ; Writing-original draft, MPI, ELA, JAVB; Writing-review & editing, MPI, ELA, JAVB, AZ, MG, DC.

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Nutritional Status and Risk of Sarcopenia among Hospitalized Older Adults Residing in a Rural Region in Turkey

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Background: This study aimed to determine the prevalence of sarcopenia and its associated factors in community-dwelling older adults at risk of malnutrition based on the Mini Nutritional Assessment (MNA), Prognostic Nutritional Index (PNI), and Geriatric Nutritional Risk Index (GNRI). **Methods:** The study participants were 345 adults aged >65 years who visited Geriatric Internal Medicine outpatient clinics. The study included people without acute illness for whom the risk of malnutrition could be assessed and appropriate measurements taken. At the baseline visit, participants' data and measurements were gathered. The primary data included sociodemographic details, anthropometric measurements, malnutrition screening tests, and functional assessments. **Results:** The participants' mean age was 76.21±5.59 years, and 57.1% were men (n=97). The prevalence rate of sarcopenia was 45.5%. Compared to individuals without sarcopenia, those with it were older; had lower MNA, PNI, and GNRI scores; and had lower muscle mass, muscle strength, and lower leg circumferences (p<0.001). After adjusting for potential confounding factors, we found that sarcopenia, advanced age, male sex, high risk of malnutrition, calf circumference, and a low PNI score were all significantly associated with a low GNRI score (p<0.001). **Conclusion:** Sarcopenia was significantly associated with advanced age, male sex, and high risk of malnutrition. Patients' nutritional and functional status should always be assessed for therapeutic interventions and lifestyle changes.

Key Words: Elderly, Malnutrition, Nutrition assessment, Nutritional status, Sarcopenia

INTRODUCTION

Aging is an inevitable process in which cells, organs, and entire systems change and show functional decline.[1] In Turkey, people aged ≥65 years are expected to comprise 9.9% of the total population by 2022.[2] As people age, they experience respiratory, cardiovascular, digestive, nervous, endocrine, immune, musculoskeletal, excretory, dermatological, ocular, otological, gustatory, and olfactory problems. Most individuals >65 years of age also have multiple chronic systemic diseases and take multiple drugs.[3] Sarcopenia and malnutrition are the most common health problems and show similar physiological mechanisms in this population.[4] Sarcopenia is a progressive and generalized skeletal muscle disorder involving accelerated loss of muscle mass and function and is associated with increased adverse outcomes, including falls, functional decline, frailty, and mortality.[5] The European Society for Clinical Nutrition and Metabolism (ESPEN) defines malnutrition as a condition resulting from inadequate nutrient intake or an unhealthy diet, resulting in a change in body composition (lower lean mass and body cell mass), physical and mental function, and deterioration in clinical disease outcomes.[6] Owing to inadequate nutrition, malnutrition develops first, triggering sarcopenia development.[7,8] Thus, determining the nutritional risk, providing early treatment to slow disease progression, and ensuring the initiation of effective sarcopenia treatment in older adults are critically important. For this purpose, some nutritional screening tools and risk indices have been defined for use in older adult populations. These tools and indices are easy to apply in clinical practice, fast, low-cost, acceptable, meet high specificity and sensitivity criteria, and are suitable for continuous application.[9)]

The Mini Nutritional Assessment (MNA) and Geriatric Nutritional Risk Index (GNRI) are among the preferred nutritional screening tools in the older adult population. MNA consists of 18 questions and is the most popular test used to assess the nutritional status of older adults. It is used to gather data on anthropometric measurements, lifestyle, food consumption, and subjective health[10-12)] GNRI is universally adopted to evaluate patients' nutritional condition. It is an effective and simple risk index to present patients' nutritional risk and has been proven to be a predictive index for prognosis in aged patients, patients on dialysis, patients with cardiovascular conditions, and in healthcare contexts.[11)] The Prognostic Nutritional Index (PNI) is used to determine the risk of nutrition-related complications in patients undergoing surgery.[13)]

The European Working Group on Sarcopenia in Older People (EWGSOP) has made several updates over the last 10 years to standardize the definition of sarcopenia. These guidelines use low muscle strength, considered the most reliable measure of muscle function, as the primary parameter for sarcopenia.[14)] The most common methods for evaluating muscle mass are dual-energy X-ray absorptiometry (DEXA), computed tomography, magnetic resonance imaging (MRI), bioimpedance analysis (BIA), total and partial body potassium/fat-free soft tissue ratios, and anthropometric measurements. The method used depends on cost and facilities.[15)] Gait speed, hand grip strength, and/or muscle mass are recommended to screen for sarcopenia starting at 65 years of age.[16)] The term malnutrition–sarcopenia syndrome was coined to describe the simultaneous occurrence of both malnutrition and sarcopenia, most notably in older adults, and has a higher mortality rate than that for either condition alone.[17)]

Older adults require adequate and nutritious food.[18)] Older adults in rural regions are more vulnerable to sarcopenia than those living in urban areas.[19)] Malatya, the province in which this study was conducted, is located in Eastern Anatolia, Turkey. People aged ≥ 65 years constitute 10%–12% of the total population in this province.[2)] This study aimed to determine the nutritional status and the risk of sarcopenia in hospitalized older adults in Malatya, a rural region in Turkey.

MATERIALS AND METHODS

The inclusion criteria of the study were individuals aged ≥ 65 years hospitalized at the Malatya Turgut Ozal University Medical Faculty Hospital and who volunteered to participate in the study. The exclusion criteria were people aged < 65 years; those with dementia or Alzheimer disease, cognitive or mental impairment, end-stage kidney disease, or cancer, unable to communicate, or who did not agree to participate.

Data Gathering Instruments

Information collection forms were completed by researchers during in-person interviews with the patients. The questionnaire consisted of four sections containing sociodemographic data, health information, nutrition screening tests, and anthropometric measurements, respectively.

Anthropometric Measurements and Hand Grip Strength

Calf circumference

Calf circumference was measured from the widest part of the calf in the sitting position using a non-stretchable tape measure with the ankle and knee at 90°. The same measurement was performed on bedridden participants. Calf circumference reflects a change in the lean muscle mass with age.[20)]

Height

The presence of diseases (e.g., arthritis, osteoporosis, spinal deformity, and various neuromuscular diseases), dependence on a bed or wheelchair, and kyphotic posture that occur with aging make it difficult to accurately measure the height of older adults. Inaccurate measurement leads to misleading estimations of nutritional status. Therefore, knee length measurement is recommended to avoid this problem. The present study used the following formula to calculate height using the knee length, age, and sex.

Knee length was used to measure the correct height in elderly individuals who were bed- or chair-bound and cannot stand upright. Knee length was measured using a sliding caliper with the knee and ankle upright at 90°.

Men: 64.19 – (0.04 × age) + (2.02 × knee length)
Women: 84.88 – (0.24 × age) + (1.83 × knee length)

Body weight

The body weight of older adults who could move independently was measured with a weighing device sensitive to 0.1 kg. The participants stood on a flat, hard, and stable surface, and wore thin clothes and no shoes. During the measurements, care was taken that the participants did not lean on anything or apply any outside force.

Body mass index

Body mass index (BMI) is a practical method for detecting obesity and protein–energy malnutrition. It is calculated by dividing the body weight (kg) by the square of the height (m^2). Changes in BMI in older adults vary depending on the loss of lean tissue, in addition to adipose tissue. The absence of a consensus cutoff point for the assessment of BMI in older adults reduces its validity in determining nutritional status. We applied the World Health Organization (WHO) BMI values for adults.

Hand Grip (muscle) strength

Hand grip strength was measured using a mechanical dynamometer (EASYCARE Hand Dynamometer; Fabrication Enterprises, Elmsford, NY, USA) with a scale of 0–100 kg and a precision of 1.0 kg.[21)] The participants were instructed to put all their strength into grasping the instrument while it was held vertically in front of them, with their free arm hanging freely from their side. The measurement was performed twice on each hand (right and left) and all three values, in addition to the mean value provided by the instrument, were recorded. These measured values were compared with reference values determined based on the participants' age and sex.[22)]

GNRI

We calculated GNRI using the formula "1.489 × serum albumin (g/L) + 41.7 * (body weight in kilograms/ideal body weight)."

The formula "22 × square of height in meters" was used to determine the ideal body weight. In GNRI, scores > 112.3, 103.8–112.3, and < 103.8 indicate mild, moderate, and severe malnutrition, respectively.[23)]

PNI

We calculated PNI using the formula "10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (mm^3)." In PNI, scor es > 56.1, 50.0–56.1, and > 50.0 indicate normal, mild to moderate, and severe malnutrition, respectively.[24)]

MNA

MNA offers an easy and rapid method to evaluate the nutritional status of older adult patients in outpatient clinics, hospitals, and nursing homes. In the MNA screening test, the best option is marked. At the end of the test, the scores are summed. The screening test consists of two stages; the screening phase, followed by the evaluation phase. In the screening stage, a score of 12–14 points denotes a normal nutritional status, 8–11 points denotes a risk of malnutrition, and 0–7 points denotes malnourishment in older adults. Scores of 24–30, 17–23.5, and < 17 points in the screening and evaluation sections denote normal nutritional status, risk of malnutrition, and malnutrition, respectively.[25)]

Evaluation of Sarcopenia Status

The evaluation of an individual's muscle mass, muscle strength, and physical performance are all necessary steps in the diagnosis of sarcopenia. Various approaches are used to assess these three aspects. We measured the total muscle mass of each participant using Lee's equation, with muscle masses < 7.0 kg in men and < 5.4 kg in women defined as "low."[26)] We measured muscle strength using the hand strength tightening method, with grip strengths of < 20.0 kg in women and < 30.0 kg in men categorized as "weak" based on the older adult diagnostic algorithm from the EWGSOP. We assessed each participant's level of physical performance using the get-up-and-go test, with < 0.8 m/s as the threshold. Low walking speed was defined with < 0.8 m/s as the threshold.[27)]

Muscle mass (kg) = (0.244 × BMI) + (7.8 × height [m]) + (6.6 × sex [M:1; F:0]) – (0.098 × age) + (ethnicity – 3.3)

where calculation of ethnicity was made by assigning values of 0, 1.4, and 1.2 for White and Hispanic, African, and Asian, respectively.

Statistical Analysis

We performed the statistical analyses using IBM SPSS Statistics for Windows (version 22.0; IBM Corp., Armonk, NY, USA). Normality was assessed visually (histograms and probability plots) and analytically (Kolmogorov–Smirnov/Shapiro–Wilk tests). The chi-square test was used to compare proportions between groups. We applied Student t-test to compare the results between groups for normally distributed continuous variables. Continuous variables are presented as means and standard deviation, whereas categorical variables are shown as percentages and numbers. We applied the Mann–Whitney U test to compare nonnormally distributed continuous parameters between the groups.

We examined the relationship between muscle mass and strength using univariate regression analysis. Odds ratios were modified for other variables including BMI, age at baseline, polypharmacy, nutritional status indicators, and malnutrition status. The univariate regression model had statistically significant variables added as potential confounders. Statistical significance was set at $p < 0.05$.

Ethics Statement

This study was approved by the Ethics Committee of Mardin Artuklu University (Approval No. 2023/15-15). Before beginning the survey, all the respondents read a written consent form and voluntarily consented to participate.

Also, this study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[28)]

RESULTS

The mean age of the study participant was 76.21 ± 5.59 years, with 55.65% of the participants 65–74 years of age and 42.90% women. Three or more chronic diseases were present in 36.23% of the participants, and 23.48% used three or more drugs per day (Table 1). According to the sarcopenia criteria, 45.50% of the participants had sarcopenia.

The results of the comparisons of age and anthropometric characteristics of the participants according to their sarcopenia status are shown in Table 2. The muscle mass, muscle strength, and calf circumference differed significantly according to sarcopenia status, with lower values in participants of both sexes with sarcopenia ($p < 0.05$).

Table 3 shows the relationships between sarcopenia and malnutrition indices of individuals according to sex. The MNA-SF and GNRI scores of participants with sarcopenia were lower than those in individuals without it for both sexes ($p < 0.05$). The PNI scores were lower in those with sarcopenia individuals than in those without sarcopenia group in women ($p < 0.05$) but not in men ($p > 0.05$).

The factors affecting muscle mass and strength are listed in Table 4. The most important factor was MNA score ($p < 0.05$), followed by age, BMI, and GNRI (all $p < 0.05$). Muscle mass was also affected by PNI score and calf circumference ($p < 0.05$). Muscle mass and strength in men were influenced by BMI, PNI, and GNRI scores ($p < 0.05$). In addition, the number of prescribed drugs was an important factor affecting muscle mass in men ($p < 0.05$) but not in women ($p > 0.05$).

DISCUSSION

Care for older adults is a new and developing service model in Turkey. This study is one of the few that examine the nutritional status

Table 1. General characteristics of individuals (n=345)

	Value
Age (y)	76.21 ± 5.59
65–74 (young seniors)	192 (55.65)
75–84 (middle-aged)	81 (23.48)
≥ 85 (advanced old people)	72 (20.87)
Sex	
Female	148 (42.90)
Male	197 (57.10)
Living place	
With her family	238 (68.99)
Lives alone	107 (31.01)
Marital status	
Married	221 (64.06)
Single	124 (35.94)
Educational status	
No read and write	108 (31.30)
Read-write only	119 (34.49)
Primary school	45 (13.04)
Middle school and above	73 (21.16)
Number of chronic diseases	
None	12 (3.48)
1	96 (27.83)
2	112 (32.46)
≥ 3	125 (36.23)
Number of drugs used daily	
0	41 (11.88)
1	77 (22.32)
2	156 (45.22)
≥ 3	81 (23.48)

Values are presented as mean±standard deviation or number (%).

Table 2. Age and anthropometric characteristics of individuals according to their sarcopenia status

	All individuals			Female			Male		
	Sarcopenic (n = 157)	Non-sarcopenic (n = 188)	p-value[a)]	Sarcopenic (n = 89)	Non-sarcopenic (n = 79)	p-value[a)]	Sarcopenic (n = 68)	Non-sarcopenic (n = 109)	p-value[a)]
Age (y)	74.30 ± 8.11	73.94 ± 6.21	0.201	78.25 ± 7.07	75.19 ± 5.12	0.108	79.30 ± 9.76	70.09 ± 4.65	0.032*
BMI (kg/m^2)	22.05 ± 1.63	21.33 ± 2.39	0.501	22.19 ± 2.21	23.01 ± 3.14	0.231	23.56 ± 1.17	23.99 ± 2.39	0.399
Muscle mass (kg)	24.22 ± 3.25	27.88 ± 3.44	0.001*	18.24 ± 2.25	20.22 ± 2.75	0.001*	24.75 ± 2.35	25.24 ± 3.21	0.297
Muscle strength,hand grip (kg)	28.32 ± 3.52	32.5 ± 7.52	0.039*	22.21 ± 4.55	25.21 ± 5.45	0.006*	29.52 ± 6.52	32.88 ± 4.59	0.046*
Muscle mass index (kg/m^2)	9.21 ± 1.25	9.33 ± 1.88	0.293	8.33 ± 1.54	8.75 ± 1.45	0.391	10.22 ± 1.68	11.25 ± 2.01	0.102
Calf circumferences (cm)	30.34 ± 3.60	32.38 ± 2.56	0.225	26.18 ± 2.26	29.45 ± 2.18	0.001*	30.15 ± 3.15	34.35 ± 3.75	0.001*

Values are presented as mean±standard deviation.
BMI, body mass index.
[a)]Mann-Whitney U test (*$p<0.05$).

Table 3. Malnutrition indices and distributions of individuals according to sarcopenia and sex

Malnutrition index	All individuals	Female			Male		
		Sarcopenic (n = 89)	Non-sarcopenic (n = 79)	p-value	Sarcopenic (n = 68)	Non-sarcopenic (n = 109)	p-value
MNA SF	11.21 ± 1.12	7.23 ± 1.45	12.13 ± 2.13	0.024a)*	8.14 ± 1.67	14.21 ± 2.91	0.014a)*
Malnutrition	54.49	46.07	21.52		32.11	26.61	
At risk of malnutrition	28.12	24.72	37.97		15.60	33.94	
Normal nutrition starus	17.39	29.21	40.51	0.006**	14.68	39.45	0.001b)*
GNRI	109.14 ± 7.21	94.21 ± 11.13	98.12 ± 8.21	0.051a)	106.21 ± 7.19	114.28 ± 7.94	0.022a)*
Normal	28.70	12.36	35.44		11.01	42.20	
Moderate malnutrition	57.10	33.71	30.38		33.03	30.28	
Malnutrition	14.20	53.93	34.18	0.028*	18.35	27.52	0.041b)*
PNI	54.13 ± 3.27	48.19 ± 4.46	51.21 ± 3.28	0.001*	44.13 ± 2.55	49.24 ± 2.25	0.081a)
Normal	25.22	10.11	26.58		12.84	44.04	
Moderate malnutrition	55.65	39.33	49.37		20.18	33.03	
Malnutrition	19.13	50.56	24.05	0.104	29.36	11.01	0.007b)*

Values are presented as mean±standard deviation.
MNA-SF, Mini Nutritional Assesment-Short form; GNRI, Geriatric Nutritional Risk Index; PNI, Prognostic Nutrition Index.
[a]Mann-Whitney U test, [b]chi-squared test.
*p<0.05, **p<0.01.

Table 4. Multiple linear regression analysis of factors affecting muscle strength and muscle mass in individuals by sex

	Female				Male			
	Muscle mass		Muscle strength		Muscle mass		Muscle strength	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age (y)	1.011 (0.804–1.689)	< 0.05	0.944 (0.806–1.291)	< 0.05	0.809 (0.741–1.291)	< 0.05	0.704 (0.604–1.008)	< 0.05
MNA score	1.401 (0.991–2.285)	< 0.05	1.201 (1.341–2.344)	< 0.05	1.390 (1.103–3.467)	< 0.05	1.109 (0.956–1.690)	< 0.05
Number of prescribed drugs currently taking	0.287 (0.101–0.581)	> 0.05	0.351 (0.104–0.456)	> 0.05	0.290 (0.089–0.401)	< 0.05	0.451 (0.045–0.521)	> 0.05
Calf circumferences	0.678 (0.521–1.701)	< 0.05	0.809 (0.771–1.506)	< 0.05	0.901 (0.856–1.772)	< 0.05	1.102 (1.055–2.809)	< 0.05
BMI (kg/m^2)	1.002 (0.569–1.991)	< 0.05	1.190 (0.951–2.175)	< 0.05	1.412 (0.890–4.104)	< 0.05	1.249 (1.031–1.706)	< 0.05
PNI score	0.798 (0.490–1.809)	< 0.05	1.301 (1.101–2.781)	< 0.05	1.291 (0.801–1.706)	< 0.05	0.991 (0.761–1.045)	< 0.05
GNRI score	0.959 (0.641–3.701)	< 0.05	1.003 (0.871–2.145)	< 0.05	1.079 (1.009–1.760)	< 0.05	1.181 (0.831–1.291)	< 0.05

MNA, Mini Nutritional Assessment; BMI, body mass index; PNI, Prognostic Nutrition index; GNRI, Geriatric Nutritional Risk Index; OR, odds ratio; CI, confidence interval.

of older care patients with sarcopenia in Turkey. Our results showed that the prevalence of malnutrition is quite high in general and reflects sarcopenia in patients receiving hospital care.

In this study, 55.7% of the older adults were aged 65–74 years. According to the Turkish Statistical Institute (TSI) in 2022, 64.5% of the elderly population in Turkey is 65–74 years of age, and this age range is consistent with the proportions of hospitalized older adults.[2] In the present study, 42.9% of the participants were women and 57.1% were men. According to the TSI-2022 data, the prevalence of older adult women is higher than that of men in Turkey (F, 55.7%; M, 44.3%).[2] Moreover, 61.1% of women and 49% of men had visited a health institution in the last 3 months.[29] One explanation for the predominance of men in this study was a higher number of hospital admissions due to the number of chronic diseases and multiple drug use rates compared to women. Sarcopenia and malnutrition are associated with negative health outcomes including falls, fractures, physical disability, frailty, poor quality of life, and mortality. Therefore, early diagnosis is important, especially in older adults, to prevent sarcopenia and malnutrition in a timely manner and allow early treatment interventions.[30] BMI values of 23–29.9 kg/m^2 have been associated with optimal life expectancy in older adults. The risk of death increases in older adults with BMI < 23 kg/m^2.[31] The mean BMI values were 22.1 kg/m^2 and 21.3 kg/m^2 among the participants in this study with and without sarcopenia, respectively. BMI was a risk factor in both groups. Yanishi et al.[32] Chien et al.[33] and Siegert et al.[34] reported higher BMI in individuals without sarcopenia compared to those with it. However, Prior et al.[35] observed no significant differences between the BMIs of 76 middle-aged and older adults with and without sarcopenia. We observed similar results regarding BMI values as those in the study by Prior et al.[35]

Regardless of BMI, malnutrition in older adults exacerbates the age-related loss of muscle mass and plays a role in sarcopenia.[7] A previous study found that participants with both sarcopenia and a high risk of malnutrition have a four-fold higher mortality risk compared to participants with normal nutrition and without sarcopenia[17]; therefore, sarcopenia screening in conjunction with nutritional assessment is crucial.[36] The components of sarcopenia are based on the loss of muscle mass and strength with poor nutritional parameters. A recent systematic review reported a sarcopenic ratio of 10% in older adults; however, the measurement instruments vary among studies.[37] In this study, three different instruments used to measure sarcopenia. A hand-grip dynamometer was used to measure hand-grip strength, usual gait speed was used to gauge physical performance, and calf circumference was used as a proxy for muscle mass. The hand-grip strength thresholds recommended by the EWGSOP are <16 kg for women and <27 kg for men. EWGSOP-2 suggests that each community should set its own threshold values.[14] Accordingly, the threshold values for hand grip strength in Turkey are <22 kg for women and <32 kg for men.[38] In the present study, the average hand-grip strength of the sarcopenic individuals was 28.3 kg. In their study of participants with sarcopenia, presarcopenia, and no sarcopenia, Chien et al.[33] reported that hand-grip strength did not differ significantly between individuals. However, the grip strength of individuals without sarcopenia was higher than that of individuals with it in the studies by Moreira et al.[39] in middle-aged women in Northeast Brazil, Siegert et al.,[34] Yanishi et al.,[32] and Di Monaco et al.[40] in 138 women, and Woo et al.[41] in Chinese women and men. Similarly, in our study, the grip strength of participants with sarcopenia was lower because of decreased muscle strength. Therefore, regular follow-up of individuals with sarcopenia is important.

WHO regards calf circumference as the most accurate anthropometric standard for determining muscle mass in older adults.[42] In 2019, the EWGSOP revised its criteria to include calf circumference as a diagnostic proxy for older adults in areas lacking access to other methods of diagnosing muscle mass.[43] In the present study, the mean calf circumference in individuals with sarcopenia was 30.3 cm. Low calf circumference is an important predictor of mortality and frailty in older adults.[44] Kuhama et al.[45] reported greater right and left calf circumferences in individuals without sarcopenia compared to those with it. Similarly, we observed greater calf circumference measurements in both men and women without sarcopenia. In addition, calf circumference measurement was significantly associated with muscle mass and muscle strength in the present study.

Decreased muscle mass is a common characteristic of malnutrition and sarcopenia. Malnutrition directly contributes to the sarcopenia development. A previous study showed that the risk of developing sarcopenia was 13 times higher in malnourished or older adults at risk of malnutrition than in individuals with a normal nutritional status.[46] In another study, >80% of participants with sarcopenia were malnourished or at risk of malnutrition according to the MNA.[47] In the present study, the malnutrition index scores were lower in individuals with sarcopenia compared with those without sarcopenia. The most important factor affecting muscle mass and strength in both sexes was the MNA score, followed by age, BMI, and GNRI. In addition, the number of prescribed drugs was an important factor affecting muscle mass in men. Nutritional screening tools have revealed that factors affecting food intake and malnutrition are associated with sarcopenia in older adults living in rural areas. Our findings are supported by those of other studies reporting the association of sarcopenia with advancing age, low BMI, and malnutrition indices.[48-50]

The most important limitation of this study was its cross-sectional design, which prevented the generalization of these findings to other older adult populations. Moreover, we were unable to use techniques regarded as gold standards to assess muscle mass, such as DEXA, computed tomography, and MRI. Instead, we substituted the calf circumference measurements for actual muscle mass. While the lack of use of these gold-standard techniques can be seen as a limitation, a strength of this study was that we optimized our measurements according to our study objectives.

In conclusion, malnutrition and sarcopenia, which are common conditions in older adults, have negative effects such as higher morbidity and mortality, as well as higher healthcare costs and rehospitalizations. A healthy diet and regular exercise can prevent these two conditions. Each condition is typically screened separately, and they are rarely assessed simultaneously. A patient's nutritional and functional status should always be assessed to discuss therapeutic interventions and lifestyle changes, as many patients exhibit both malnutrition and sarcopenia (i.e., an increase in protein intake and physical activity). The results of our study will inform future studies, since the study region is rural and has a high ratio of older adult population to the total population.

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CONFLICT OF INTEREST

The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization, NA, HA, YS; Data curation, NA, HA, YS; Supervision, NA, HA, YS. Investigation, NA, HA, YS; Writing-original draft, NA, HA, YS; Writing-review & editing, NA, HA, YS.

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Association of Vulnerability Screening on Hospital Admission with Discharge to Rehabilitation-Oriented Care after Acute Hospital Stay

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Background: The short Dutch Safety Management Screening (DSMS) is applied at hospital admission of all patients aged >70 years to assess vulnerability. Screening of four geriatric domains aims to prevent adverse outcomes and may support targeted discharge planning for post-acute care. We explored whether the DSMS criteria for acutely admitted patients were associated with rehabilitation-oriented care needs. **Methods:** This retrospective cohort study included community-dwelling patients aged ≥70 years acutely admitted to a tertiary hospital. We recorded patient demographics, morbidity, functional status, malnutrition, fall risk, and delirium and used descriptive analysis to calculate the risks by comparing the discharge destination groups. **Results:** Among 491 hospital discharges, 349 patients (71.1%) returned home, 60 (12.2%) were referred for geriatric rehabilitation, and 82 (16.7%) to other inpatient post-acute care. Non-home referrals increased with age from 21% (70–80 years) to 61% (>90 years). A surgical diagnosis (odds ratio [OR]=4.92; 95% confidence interval [CI], 2.03–11.95), functional decline represented by Katz-activities of daily living positive screening (OR=3.79; 95% CI, 1.76–8.14), and positive fall risk (OR=2.87; 95% CI, 1.31–6.30) were associated with non-home discharge. The Charlson Comorbidity Index did not differ significantly between the groups. **Conclusion:** Admission diagnosis and vulnerability screening outcomes were associated with discharge to rehabilitation-oriented care in patients >70 years of age. The usual care data from DSMS vulnerability screening can raise awareness of discharge complexity and provide opportunities to support timely and personalized transitional care.

Key Words: Frailty, Subacute care, Rehabilitation, Transitional care, Patient discharge

INTRODUCTION

A growing number of older hospital patients can benefit from rehabilitation-oriented post-acute care (PAC) to improve their functional outcomes after hospital discharge.[1,2] However, age is not an identifying criterion for referral for geriatric rehabilitation. Rather, multidisciplinary assessments and geriatric expertise must establish a genuine need for geriatric rehabilitation in older or more vulnerable hospital patients.[3,4] These PAC decisions extend across healthcare settings and are professionally and managerially challenging for hospital teams.[5-9]

To support PAC decision-making and enhance the coordination of services following discharge from the hospital, discharge planning should preferably start from admission by following candidates for PAC.[10-12] Patient characteristics such as older age, female sex, frailty, lower functional or cognitive status at admission, comorbidities, and length of hospital stay are associated with the development of rehabilitation needs and functional impairments during hospital stays.[13-15] To prevent functional decline in vulnerable patients and other adverse outcomes such as institutionalization, various vulnerability screening instruments have been developed.[16-18] The vulnerability score of the mandatory Dutch Safety Management System (DSMS) was introduced in Dutch hospitals in 2012 and has been applied to all patients aged > 70 years at admission. The DSMS tool consists of short screening instruments in four geriatric domains: delirium, functional impairment, malnutrition, and fall risk.[19-22]

Early identification of vulnerable older patients at hospital admission aims to diminish the risk of functional decline during the hospital stay through targeted in-hospital geriatric interventions. Subsequently, early and repeated assessments of rehabilitation needs, exploration of individual motivation, and establishment of an individual prognosis for recovery may identify candidates for geriatric rehabilitation early during their hospital stay and enhance personalized PAC decision-making.[11,12] Although the mandatory DSMS screening of seniors at hospital admission was not designed nor validated to identify patients to undergo rehabilitation, an association could exist between the “risk of adverse outcome profile” in these patients and the appropriateness of rehabilitation-oriented care at discharge. Early profiling of potential geriatric rehabilitation candidates using available demographic and clinical admission data, including vulnerability scores, may allow for early decision-making concerning rehabilitation-oriented PAC. We hypothesized that DSMS vulnerability scores would differ between patients referred for geriatric rehabilitation and those discharged home. Therefore, we sought to identify patient characteristics related to the DSMS screening domains that were associated with referral to rehabilitation-oriented care after an acute hospital stay.

MATERIALS AND METHODS

Setting and Design

Amsterdam University Medical Centers is a large (1,700-bed) tertiary academic medical center with two facilities. Both hospitals are situated in an urban health region and provide specialized medical care to a large, predominantly urbanized region. One hospital has a geriatric rehabilitation unit. Skilled nursing facilities, nursing homes, and private care organizations in the area provide rehabilitation-oriented PAC consisting of geriatric rehabilitation and short-stay residential care. Short-stay residential care is indicated when older patients require temporary nursing home care for recovery.[23] We undertook a retrospective cohort study of community-dwelling patients aged > 70 years who were discharged from the hospital between January 15 and May 15, 2019.

Patients

This study included hospital episodes of community-dwelling patients aged > 70 years discharged after acute admission from a single facility. Acute admission was defined as an admission following emergency room admission. The minimum hospital stay was one night. If a patient was admitted more than once during the study period, we included the last hospital episode following the acute admission. We excluded admitted patients who had died and those discharged from other hospitals, and included patients discharged to the in-hospital geriatric rehabilitation unit. Three subgroups of patients were formed according to discharge destination: home, geriatric rehabilitation, and other PAC in a nursing home. Usual care data were extracted from the patients’ medical records. The demographic variables included age, sex, place of residence before admission, and discharge disposition (home, nursing home, or other hospital). Data on the living conditions were not available. Clinical data included attending medical specialty; admission diagnosis; comorbidities; and DSMS data on functional status, nutritional status, falling risk, and presence of delirium symptoms. We collected DSMS data within 48 hours of admission and information concerning consultant specialists, paramedical treatment, and length of hospital stay. The discharge destination for inpatient PAC was geriatric rehabilitation or other nursing home care.

Measurement Instruments

Table 1 presents the vulnerability screening system of the DSMS. This system consists of the Simplified Nutritional Assessment Questionnaire (SNAq) for nutritional status, Katz activities of daily living (ADL) for functional status, and screening questions for delirium and falls.[24-26] In the population under study, the adapted version of DSMS was used. The falling risk was assessed using the Johns Hopkins Risk of Falls Assessment Tool (JHRFAT) instead of a single question regarding the history of falls. The JHRFAT is widely used for measuring age, fall history, incontinence, medication use, use of patient-care equipment, mobility, and cognition. Scores of 6–13 and > 13 points indicate moderate and severe fall risks, respectively.[27,28] We used the Delirium Observation Screening Scale (DOS) to identify the confusion symptoms. The DOS comprises 13 items in seven domains (consciousness, attention, thinking, memory/orientation, psychomotor activity, mood, and perception) and is applied to the presence of delirium symptoms instead of three screening questions on the confusion symptoms. Each item of the DOS was scored during one 8-hour nursing shift (day/evening/night). A score of three or more points was considered positive.[29,30]

In the DSMS tool, the score of each separate instrument is dichotomized into the presence or absence of risk and summed to obtain the DSMS score for vulnerability, with a range of 0–4. Vulnerability is defined as DSMS scores of ≥ 3 and ≥ 1 in patients

Table 1. Original and adapted DSMS vulnerability screening

	Original DSMS screening[22]	Adapted DSMS screening
Functional status	Katz-ADL ≥ 2 = 1 point	Unchanged
Nutritional status	SNAq ≥ 2 = 1 point	Unchanged
Falls risk	Q: Did you fall during the last 6 months? Yes = 1 point	JHRFAT ≥ 6 = 1 point
Delirium	Q: Do you have memory problems (Y/N); did you need help in basic ADL, in the last 24 hours (Y/N); did you previously experience confusion (Y/N) ≥ 1 Yes = 1 point	DOSs ≥ 3 = 1 point
DSMS score	0–4 points	Unchanged
Vulnerability	Age < 80 and ≥ 3 points Age ≥ 80 and ≥ 1 point	Unchanged

DSMS, Dutch Safety Management Screening; Katz-ADL, Katz activities of daily living score; SNAq, Short Nutritional Assessment Questionnaire; Q, question; JHRFAT, Johns Hopkins Risk of Falls Assessment Tool; DOS, Delirium Observation Screening scale.

aged 70–79 and ≥ 80 years, respectively.[17,19] Table 1 lists the components of the DSMS vulnerability score and vulnerability calculation. The age-adjusted Charlson Comorbidity Index (CCI), based on reported comorbidities, adds one point for every decade over 40 years of age.[31]

Analysis

We analyzed the data using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). According to the discharge destination after the hospital stay, the data were divided into home (H), geriatric rehabilitation (GR), and other nursing home care (NH). Comorbidity data were computed using the age-adjusted CCI.[32] When the Katz-ADL or JHFRAT scores were assessed more than once during the hospital stay, we analyzed the final score. Next to DOSs ≥ 3, the number of positive DOSs (≥ 3) was used as an additional variable.

Data were analyzed according to the discharge destination (H, GR, and NH). For analysis of total inpatient PAC discharge, the GR and NH groups were combined to form the "non-home group." We performed comparisons between groups using χ^2 tests for nominal data, Kruskal-Wallis tests for ordinal data, and t-tests for normally distributed continuous data. According to the original DSMS screening, the scores of the adapted DSMS were dichotomized into the presence or absence of risk to calculate the vulnerability score. We calculated the odds ratio (OR) with 95% confidence intervals (CI) of the independent variables "age," "surgical diagnosis," "age-adjusted CCI," and the DSMS criteria using logistic regression analysis comparing home and non-home discharge. Bivariate correlations were evaluated (Pearson coefficient). To calculate the OR for age-adjusted CCI, we dichotomized the data according to the median value (6) in our cohort.[33,34]

Ethics

The Medical Ethics Committee of the University Medical Centers Amsterdam reviewed and approved the study protocol (File No. 2018621). Also, this study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[35]

RESULTS

Fig. 1 shows a flow diagram of the study inclusion process. Among 491 total patient records included in this study, 349 (71.1%) patients were discharged H, 60 (12.2%) to GR, and 82 (16.7%) to NH. In the NH group, most (75.6%) were referred for short-stay residential care, recovery care in a nursing home for general medical needs that did not require medical specialist care, or GR.[23] A minority of this group (24.4%) was referred for palliative intermediate or long-term care. Supplementary Table S1 provides an overview of the NH group.

Demographics and Comorbidities

Overall, 55.4% of the patients were male. In the H group, 59.3% were men. The sexes were evenly matched in the GH group and were 42.7% in the NH group.

In the 71–80-years age group, 79% were discharged H group, 11% to GR group, and 10% to NH group. In patients > 90 years of age, 39% were discharged H group, 23% to GR group, and 38% to NH group. An overview of the data is presented in Table 2.

Among GR patients, 70% were acute orthopedic or trauma patients, in contrast to the H group with 12.6% surgical patients. Internal medical patients comprised 35.5% of the H group, 5.0% of the GR group, and 40.2% of the NH group. Neurological or neurosurgical patients comprised 12.9% of the H-group, 8.3% of the GR group, and 25.7% of the NH group. The mean age-adjusted CCI

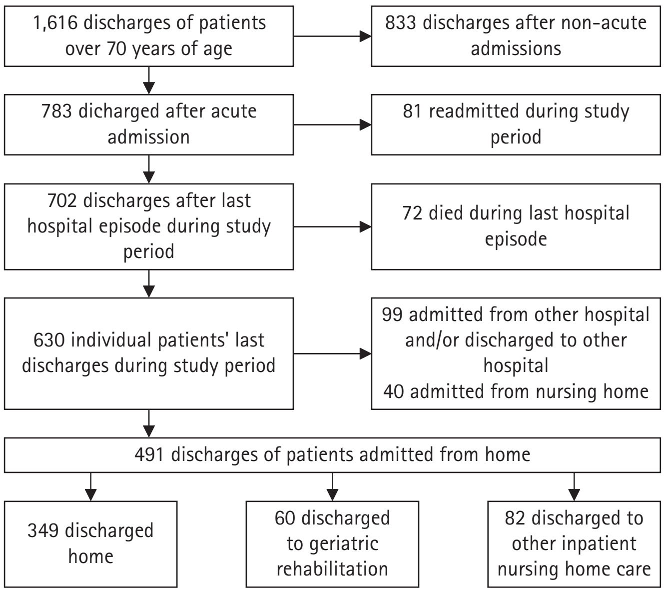

Fig. 1. Flow diagram of inclusion.

was 7.18 in the H group, 7.57 in the GR group, and 7.65 in the NH group (p = 0.186). Overviews of the comorbidity data and main diagnoses are presented in Supplementary Tables S2 and S3.

DSMS-Vulnerability Screening

DOS scores were missing for 52% of the participants, SNAq scores in 16%, and Katz-ADL in 13%.

The JHFRAT data were complete. Symptoms of delirium (DOS ≥ 3) were present in 37% of the H patients, 49% of GR patients, 63% of NH patients, and 57% of all non-home discharged patients. Delirium symptoms registered on 2 or more days were present in 6% of H-group patients, 16% of GR patients, 27% of NH, and 22% of all non-home patients. Functional status was low in 28% of patients discharged home compared to 79% of GR patients, 69% of NH patients, and 73% of all non-home discharged patients. A medium or high risk of falling was observed in 52% of participants in the H-group, 73% of the GR group, 82% of the NH group, and 78% of all non-home discharged patients.

DSMS vulnerability scores were present in 30% of H group patients and 70% of NH patients. Vulnerability, according to DSMS scoring was present in 44% of H-group patients, 67% of GR patients, 75% of NH patients, and 72% of all non-home discharged patients. Table 3 presents an overview of the data. The graphs are provided in Supplementary Figs. S1 and S2.

Non-home Discharge

Patients with trauma or acute orthopedic needs (adjusted OR = 4.92; 95% CI, 2.03–11.95) had higher odds for non-home discharge. The odds for non-home discharge were highest for patients with functional impairment, as represented by positive Katz-ADL (OR = 3.79; 95% CI, 1.76–8.13) and JHFRAT scores on the risk of falling (OR = 2.87; 95% CI, 1.31–6.29). We observed no associations between positive DOS (OR = 2.12; 95% CI, 0.99–4.55) or SNAq screening (OR = 1.64; 95% CI, 0.73–3.70) and non-home discharge. Table 4 presents an overview of the crude and adjusted ORs.

DISCUSSION

In this cohort of acutely admitted community-dwelling patients, two subscores of the DSMS vulnerability tool were associated with discharge to geriatric rehabilitation or other nursing home care. Usual care data on vulnerability contains valuable information for PAC decision-making. The most distinctive differences between home and non-home hospital discharge were the DSMS subscores for functional status (Katz-ADL) and falling risk (JHFRAT), both of which are multidomain measurement instruments.

DSMS Vulnerability Screening

Previous studies on the predictive properties of the DSMS vulnerability score have reported contradictory findings regarding early readmission and mortality in older hospital patients.[20,21,36] No association was found between DSMS vulnerability and mortality, complications, or readmission in geriatric, cardiac, or gynecological patients.[19,37-39] However, in patients with hip fractures, the DSMS vulnerability score was positively associated with mortality and a complicated rehabilitation trajectory.[40,41] Moreover, low to moderate prognostic accuracy has been reported for functional decline, morbidity, hospital readmission, institutionalization, and long-term survival.[19]

In a cohort of patients discharged from a geriatric ward, positive scores on all four domains of the DSMS vulnerability tool were associated with post-discharge institutionalization; however, the type of PAC was not specified.[22] In our cohort of older patients discharged from all hospital wards, we observed a positive association between DSMS vulnerability sub-scores and referral to rehabilitation-oriented PAC The ORs were the highest for positive Katz-ADL (functional domain) and JHFRAT (falling risk) scores. This finding is consistent with evidence that functional metrics are significant predictors of multiple hospital outcomes, including the likelihood of discharge home and the risk of poorer functional status after acute care.[42] Functional recovery and safe mobility are important geriatric rehabilitation goals. The application of DSMS screening enhances the awareness of rehabilitation needs, thus targeting potential candidates for geriatric rehabilitation at an early stage.

Table 2. Demographic characteristics, referring specialism and co-morbidity in discharge destination groups

	Home (n = 349)		Geriatric rehabilitation (n = 60)		Nursing home (n = 82)		Total (n = 491)	p-value
	Male	Female	Male	Female	Male	Female		
Age	207 (59.3)	142 (40.7)	30 (50.0)	30 (50.0)	35 (42.7)	47 (57.3)		
71-80 y (n = 283)	224/283 (79)		30/283 (11)		29/283 (10)			
	134/224 (64.8)	90/224 (63.4)	19/30 (63.3)	11/30 (36.7)	18/29 (51.4)	11/29 (23.4)	283/491 (57.7)	
	134/283 (47.3)	90/283 (31.8)	19/283 (6.7)	11/283 (3.9)	18/283 (6.4)	11/283 (3.9)		
81-90 y (n = 169)	110/169 (65)		21/169 (12)		38/169 (23)			
	68/110 (32.8)	42/110 (29.6)	9/21 (30.0)	12/21 (40.0)	13/38 (37.1)	25/38 (53.2)	169/491 (34.4)	
	68/169 (40.2)	42/169 (24.9)	6/169 (5.3)	12/169 (7.1)	13/169 (7.7)	25/169 (14.8)		
≥ 90 y (n = 39)	15/39 (39)		9/39 (23)		15/39 (38)			
	5/15 (2.4)	10/15 (7.0)	2/9 (6.7)	7/9 (23.3)	4/15 (11.4)	11/15 (23.4)	39/491 (7.9)	
	5/39 (12.8)	10/39 (25.6)	2/39 (5.1)	7/39 (18.0)	4/39 (10.3)	11/39 (28.2)		
Attending specialism	349 (100)		60 (100)		82 (100)			< 0.001
Internal medicine	124 (35.5)		3 (5.0)		33 (40.2)			
Trauma, orthopedics	44 (12.6)		42 (70.0)		17 (20.7)			
Neurology, neurosurgery	45 (12.9)		5 (8.3)		21 (25.7)			
Gastroenterology	28 (8.0)		1 (1.7)		2 (2.4)			
Cardiology	27 (7.7)		1 (1.7)		0 (0)			
Pulmonary diseases	52 (14.9)		2 (3.3)		5 (6.1)			
Other specialisms	29 (8.3)		6 (10.0)		4 (4.8)			
Comorbidity								
CCI	2.78 ± 2.918		2.92 ± 3.196		2.82 ± 3.043			0.990
Age-adjusted CCI	7.18 ± 2.966		7.57 ± 3.158		7.65 ± 2.953			0.186
Days in hospital	3 (1.0–6.0)		10 (6.0–18.5)		10 (6.0–15.8)			< 0.001

Values are presented as mean±standard deviation or median (interquartile range). For age and attending specialism, the number in parentheses denotes a percentage.
CCI, Charlson Comorbidity Index.

Non-home Discharge in Hip Fracture Patients

Most participants in the geriatric rehabilitation group in this study were patients with trauma or acute orthopedic needs and aged > 80 years. As in our study, the Dutch hip fracture cohort study found that seniority, premorbid mobility problems, and premorbid Katz-ADL were independent predictors of discharge to geriatric rehabilitation vs. home.[43] The original DSMS did not include a separate mobility screening; however, the JHFRAT in the adapted DSMS contains three mobility items: the need for supervision or assistance when walking, unsteady walking, and sensory loss affecting mobility. A positive JHFRAT score in our cohort had positive odds for non-home discharge (adjusted OR = 2.87; 95% CI, 1.31–6.29). In the Dutch hip fracture cohort, a higher premorbid Katz-ADL score and a history of dementia distinguished between discharge to a nursing home and discharge home.[43] In our study, a DOS of ≥ 3, which indicated the presence of delirium symptoms, did not show positive odds for non-home discharge from the hospital (OR = 2.12; 95% CI, 0.99–4.55). While other studies reported that delirium in patients with hip fractures was an independent predictor of adverse outcomes, our results did not confirm this association.[44-46]

Vulnerability and Discharge Decision-Making

In our cohort, a positive DSMS vulnerability score upon hospital admission indicated a certain likelihood of rehabilitation need. Being vulnerable or mildly frail does not imply the absence of rehabilitation potential.[4] The identification of future geriatric rehabilitation candidates presents an opportunity to optimize in-hospital geriatric care and personalize PAC decision-making. A positive vulnerability score inspires the exploration of all factors relevant to decision-making.

Comprehensive Geriatric Assessment (CGA), multidisciplinary

Table 3. DSMS vulnerability screening of delirium symptoms (DOSs), nutritional (SNAq) and functional (Katz-ADL) status, risk of falls (JHFRAT) in discharge destination groups

	Home (n = 349)	GR (n = 60)	NH (n = 82)	p-value	GR+NH (n = 142)	p-value
Delirium	n = 127	n = 45	n = 62		n = 107	
0DOSs ≥ 3	80 (63.0)	23 (51.1)	23 (37.1)	< 0.001	46 (43.0)	< 0.001
1 DOSs ≥ 3	19 (15.0)	7 (15.6)	10 (16.1)		17 (15.9)	
2-6DOSs ≥ 3	21 (16.5)	8 (17.8)	12 (19.4)		20 (18.7)	
≥ 7DOSs ≥ 3	7 (5.5)	7 (15.6)	17 (27.4)		24 (22.4)	
Nutritional status	n = 290	n = 54	n = 76		n = 130	
SNAq 0-1	217 (74.8)	39 (65.0)	57 (69.5)	0.960	96 (67.6)	0.991
SNAq 2	10 (3.4)	5 (8.3)	5 (6.1)		10 (7.0)	
SNAq > 2	63 (21.7)	10 (16.7)	14 (17.1)		24 (16.9)	
Functional status	n = 292	n = 57	n = 78		n = 135	
Katz-ADL < 2	210 (71.9)	12 (21.1)	24 (30.8)	< 0.001	36 (26.7)	< 0.001
Katz-ADL ≥ 2	82 (28.1)	45 (78.9)	54 (69.2)		99 (73.3)	
Risk of falls	n = 349	n = 60	n = 82		n = 142	
JHFRAT 0-6	169 (48.4)	16 (26.7)	15 (18.3)	< 0.001	31 (21.8)	< 0.001
JHFRAT 7-13	151 (43.3)	30 (50.0)	44 (53.7)		74 (52.1)	
JHFRAT > 13	29 (8.3)	14 (23.3)	23 (28.0)		37 (26,1)	
Vulnerability						
DSMS	n = 349	n = 60	n = 82		n = 142	
Completed	107 (30.6)	42 (70.0)	57 (69.5)		99 (69.7)	0.001
Vulnerable	47 (43.9)	28 (66.7)	43 (75.4)	< 0.001	71 (71.7)	< 0.001
DSMS score	n = 107	n = 42	n = 57		n = 99	
0	27 (25.2)	0 (0.0)	4 (7.0)	< 0.001	4 (4.0)	< 0.001
1	30 (28.0)	6 (14.3)	5 (8.8)		11 (11.1)	
2	25 (23.4)	21 (50.0)	15 (26.3)		36 (36.4)	
3	22 (20.6)	10 (23.8)	24 (42.1)		34 (34.3)	
4	3 (2.8)	5 (11.9)	9 (15.8)		14 (14.1)	

Values are presented as number (%).
DSMS, Dutch Safety Management Screening; DOS, Delirium Observation Screening score; SNAq, Short Nutrition Assessment Questionnaire; Katz-ADL, Katz activities of daily living score; JHFRAT, Johns Hopkins Fall Risk Assessment Tool; GR, geriatric rehabilitation; NH, inpatient nursing home care, not geriatric rehabilitation.

Table 4. Crude and adjusted odds ratios in non-home versus home discharged patients

Independent variable	Non-home vs. home	
	Crude OR (95% CI)	Adjusted OR (95% CI)
Age > 80 y	2.52 (1.69–3.76)	1.82 (0.71–4.62)
Acute orthopedic or trauma patient	4.93 (3.11–7.80)	4.92 (2.03–11.95)
Age-adjusted CCI ≥ 6	1.22 (0.89–1.68)	1.19 (0.62–2.28)
Katz-ADL ≥ 2	7.04 (4.45–11.15)	3.79 (1.76–8.13)
JHFRAT ≥ 6	5.01 (3.13–7.99)	2.87 (1.31–6.29)
DOSs ≥ 3	2.26 (1.33–3.82)	2.12 (0.99–4.55)
SNAq ≥ 2	1.05 (0.66–1.69)	1.64 (0.73–3.70)
DSMS–Vulnerability	3.24 (1.81–5.78)	0.97 (0.35–2.68)

CCI, Charlson Comorbidity Index; DOS, Delirium Observation Screening score; Katz-ADL, Katz activities of daily living score; JHFRAT, Johns Hopkins Fall Risk Assessment Tool; SNAq, Short Nutrition Assessment Questionnaire; DSMS, Dutch Safety Management Screening; OR, odds ratio; CI, confidence interval.

team meetings, and the involvement of patients and families can effectively contribute to patient-centered discharge planning.[47] Frailty measures such as the CGA-related frailty index may have prognostic value for rehabilitation outcomes.[48,49] This frailty index, as well as the DSMS vulnerability score, can be derived from automated data and facilitates discharge decision-making by allowing the early identification of patients who may later require PAC.[50]

Limitations

We analyzed the data of acutely admitted patients who were discharged from a single tertiary hospital. Both of these factors may have influenced the case mix. We assumed that the discharge of acutely admitted patients was the most representative of our research question because admission to rehabilitation-oriented PCA requires acute functional loss. This restriction and the ongoing reorganization of the two hospitals may have accounted for the change in patient flow, resulting in a high percentage of patients with trauma and a low percentage with neurological conditions in our cohort.

Our dataset has some limitations. First, due to privacy laws, data on living arrangements were not available; although living alone is an influential factor in PAC referral decisions. Second, nearly 50% of the adapted-DSMS screening data for delirium were missing. The DOS score was applied only when confusion was observed at hospital admission. The missing DOS scores explain the low percentage of completed DSMS vulnerability scores. Instructions on the application of this sub-score are important to avoid missing data. The comprehensiveness of both the DOS and JHFRAT may influence the feasibility of the DSMS.

Strengths

To our knowledge, this is the first Dutch study to address the relationship between routine vulnerability screening at hospital admission and discharge for geriatric rehabilitation. DSMS data are available in the electronic health records of all Dutch hospitals and can be used to identify potential candidates for rehabilitation-oriented PCA. These findings support hospital practices concerning geriatric treatment and facilitate the timely and careful addressing of discharge dilemmas.

As the JHRFAT in the adapted DSMS is a multidimensional "geriatric" instrument used to measure the falling risk, it may have accounted for the higher accuracy of vulnerability measurement compared to the screening question from the original DSMS.

Recommendations

DSMS vulnerability data can be used to predict discharge decisions. Timely PAC decision-making by liaison nurses, geriatricians, or rehabilitation specialists adds to the quality of transitional care. Information on living conditions and family support can further contribute to decision-making.

The inclusion of vulnerability scores in handovers can help to evaluate patient progress during rehabilitation. Frailty status may change during rehabilitation. The ADL status before hospital admission represents a parameter for goal setting in rehabilitation and supports the monitoring of functional gain.

To properly assess the association between vulnerability, appropriateness of referral decisions, and outcomes of rehabilitation-oriented PCA, we recommend a prospective cohort study with follow-up after transfer to a rehabilitation-oriented PAC.

Conclusions and Implications

DSMS vulnerability screening with a higher domain score for functional impairment and falling risk indicated higher odds for non-home discharge. Older surgical patients had the highest risk of being transferred to PCA. The usual care data of vulnerability screening at hospital admission can trigger awareness among professionals of the need for rehabilitation-oriented care at discharge, facilitating an early diligent dialogue with older patients and their families regarding preferred treatment and care after hospital discharge.

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AUTHOR CONTRIBUTIONS

Conceptualization, RB, JW, AG, CH; Data curation, AG, JW; Methodology, JW, RB, EW; Writing-original draft, AG; Writing-review & editing, EW, RB, JW, CH.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4235/agmr.23.0068.

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Perceived Stress and Frailty in Older Adults

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Background: Individuals with frailty are susceptible to adverse events. Although a psychological correlation with frailty has been observed, few studies have investigated the relationship between stress and frailty. This study examined the association between perceived stress and frailty in older adults. **Methods:** This cross-sectional observational study included participants recruited between September 2021 and January 2022. The Korean version of the Perceived Stress Scale-10 was used to measure stress levels, while the frailty status was assessed using the Korean Frailty Index. Loneliness, depression, and satisfaction were measured using the UCLA Loneliness Scale, Centre for Epidemiological Studies Depression Scale, and Satisfaction with Life Scale, respectively. We used multinomial logistic regression to compare the variables between frail and robust participants. **Results:** Among 862 study participants (mean age, 73.62 years; 65.5% women), the mean PSS-10 score was 15.26, 10.8% were frail, 22.4% were pre-frail, and 66.8% were robust. Perceived stress was significantly associated with pre-frailty (crude odds ratio [OR]=1.147; 95% confidence interval [CI], 1.093–1.204) and frailty (crude OR=1.417; 95% CI, 1.322–1.520). After adjusting for sociodemographic factors, we examined the associations between perceived stress and prefrailty (adjusted OR=1.140; 95% CI, 1.084–1.199) and frailty (adjusted OR=1.409; 95% CI, 1.308–1.518). After adjusting for all variables, including loneliness, depression, and satisfaction, perceived stress was significantly associated with frailty (adjusted OR=1.172; 95% CI, 1.071–1.283), however, insufficient statistical evidence was observed for pre-frailty (adjusted OR=1.022; 95% CI, 0.961–1.086). **Conclusion:** Higher levels of perceived stress were associated with frailty in older adults. Stress management efforts may help improve frailty in this population.

Key Words: Frailty, Psychological stress, Cross-sectional studies, Aged

INTRODUCTION

Frailty is a clinical syndrome that is associated with aging. It is characterized by the deterioration of multiple physiological functions with marked vulnerability to endogenous and exogenous stresses. Frail individuals are susceptible to adverse health outcomes, including disability, prolonged hospital stay, and mortality.[1-3] Although no definitive criteria exist for evaluating frailty, previous studies have verified multiple factors. Physical assessments include conventional approaches, such as grip strength, walking speed, and weight loss.[4] Additionally, a psychological correlation with frailty was recently reported. Adverse psychological outcomes, such as depression or anxiety, could worsen frailty status in older adults.[5] In addition, many interventions to improve psychological outcomes have been attempted, with limited effectiveness.[6,7]

As frail individuals are susceptible to adverse stress events, measuring perceived stress may help predict their frailty status. Perceived stress is the subjective concept of feelings or thoughts about one's ability to cope with problems or difficulties. Despite similar negative life events, perceived stress can differ depending on factors such as coping resources and personality.[8] Perceived stress is commonly measured using the Perceived Stress Scale,[9] which is one of the most verified measurements and has been translated into various languages, including Korean.

Most previous studies focused on the symptoms of depression or anxiety. Few studies have examined the association between stress and frailty, especially in Korea. Since South Korea is transitioning into a super-aged society with concurrent stress-laden systems, adapting to these circumstances has become demanding. Therefore, this study examined the association between perceived stress and frailty among older adults in South Korea.

MATERIALS AND METHODS

This cross-sectional, observational study recruited participants between September 2021 and January 2022. A total of 1,064 participants were enrolled from 30 senior community centers in South Korea. Each participant completed a questionnaire supervised by well-trained interviewers to collect demographic data (age, sex, highest educational level, marital status, working status, place of residence, and cohabitation status). Education level was categorized as lower than middle school and higher than high school graduation; residences as urban, suburban, and rural areas; cohabitation status as either alone or not alone, which indicated living with someone else; marital status as married or unmarried and included single, divorced, separated, and bereaved; working status as working or nonworking. The interviewers received a manual for each questionnaire and underwent training sessions before survey initiation.

We also measured perceived stress, frailty, loneliness, depression, and life satisfaction. We utilized the Korean version of the Perceived Stress Scale-10 (PSS-10),[10] which comprises 10 questions, with a total score of 40. The scores for four questions are reversed, with a higher score corresponding to a greater perception of stress. We assessed frailty status using the Korean Frailty Index (KFI),[11] a multidomain phenotype consisting of seven self-reported questions and one physical measurement. The participants were classified as robust (KFI score of 0–1), pre-frail (KFI score of 2–3), or frail (KFI score of ≥ 4). Participants with missing data were selectively included if the frailty status could be determined based on the answered questions, regardless of the score of the unanswered questions. We evaluated social isolation using the Korean version of the revised UCLA Loneliness Scale (ULS).[12] The ULS consists of 20 questions, each with 1–4 possible points. The scores of nine questions are reversed, with a higher score indicating a feeling of being more socially disconnected. We assessed depression using the Korean version of the Center for Epidemiological Studies Depression Scale (CES-D).[13,14] The CES-D consists of 11 items, each scoring 0–3 points. The scores for the two items are reversed. A cutoff score of 9 points was used to identify individuals at risk of depression. We obtained the cognitive evaluations of personal life satisfaction using the Satisfaction with Life Scale (SWLS).[15,16] The SWLS consists of five items, each scored from 1–5 points. Higher scores on the assessment are associated with higher levels of life satisfaction.

After data collection, we examined the sociodemographic characteristics and measurements. Baseline variables were summarized according to the robust, pre-frail, and frail groups using the chi-square test for categorical variables and analysis of variance (ANOVA) for continuous variables. We applied multinomial logistic regression to compare the variables of frail or pre-frail participants with those of robust participants. First, we used univariate logistic analysis to calculate the crude odds ratio (OR) for the association between frailty status and perceived stress. Next, we constructed adjusted models by sequentially adding significant variables and obtaining adjusted ORs. We calculated the ORs and 95% confidence intervals (CIs) for the pre-frailty and frailty groups. IBM SPSS Statistics for Windows, version 29.0 (IBM, Armonk, NY, USA) was used for the statistical analyses. Statistical significance was set at $p < 0.05$. This study was approved by the Institutional Review Board of Kyung Hee University (No. KHGIRB-21-389); and complied with the tenets of the Declaration of Helsinki and the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[17] Written informed consent was obtained from each participant before or at registration.

RESULTS

A total of 1,064 participants were recruited, of which 56 were excluded because of dropouts or missing age and sex data. The subsequent exclusion of 146 participants because of incomplete PSS-10 or KFI resulted in the inclusion of 862 participants in the final analysis (Fig. 1). The mean age of these participants was 73.62 ± 5.867 years and 65.5% (n = 565) were women. The mean PSS-10 score was 15.26 ± 3.991. Among the participants, 10.8% (n = 93) were frail, 22.4% (n = 193) were pre-frail, and 66.8% (n = 576) were robust. Additional descriptive data are presented in Table 1.

Perceived stress was significantly associated with pre-frailty (crude OR = 1.147; 95% CI, 1.093–1.204) and frailty (crude OR = 1.417; 95% CI, 1.322–1.520). After adjusting for sex, age, education, residence, cohabitation, marital status, and working status, the associations between perceived stress and pre-frailty (ad-

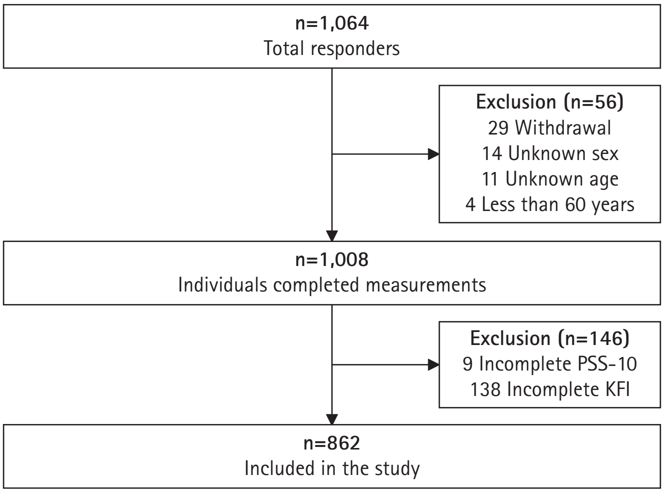

Fig. 1. Inclusion criteria of participants. PSS-10, Perceived Stress Scale-10; KFI, Korean Frailty Index.

justed OR = 1.140; 95% CI, 1.084–1.199) and frailty (adjusted OR = 1.409; 95% CI, 1.308–1.518) were statistically significant. Furthermore, after adjusting for all variables, including loneliness, depression, and satisfaction, perceived stress was significantly associated with frailty (adjusted OR = 1.172; 95% CI, 1.071–1.283). However, insufficient statistical evidence was observed between perceived stress and pre-frailty (adjusted OR = 1.022; 95% CI, 0.961–1.086) (Table 2).

DISCUSSION

Our findings demonstrated that perceived stress was associated with frailty. Frail individuals were more likely to experience higher levels of perceived stress than individuals with pre-frailty. Frailty and pre-frailty were significantly associated with age, low educa-

Table 1. Descriptive cross-sectional analysis of baseline variables

	Total (n = 862)	Robust (n = 576)	Pre-frail (n = 193)	Frail (n = 93)	p-value
Age (y)	73.62 ± 5.867	72.92 ± 5.835	74.58 ± 5.491	75.96 ± 5.993	< 0.001
Sex					0.315
Male	297 (34.5)	204 (35.4)	58 (30.1)	35 (37.6)	
Female	565 (65.5)	372 (64.6)	135 (69.9)	58 (62.4)	
Education[a]					< 0.001
Low	376 (43.6)	219 (38.0)	107 (55.4)	50 (53.8)	
High	474 (55.0)	350 (60.8)	82 (42.5)	42 (45.2)	
Missing	12 (1.4)	7 (1.2)	4 (2.1)	1 (1.0)	
Residence					0.822
Urban	471 (54.6)	314 (54.5)	109 (56.5)	48 (51.6)	
Suburban	267 (31.0)	183 (31.8)	55 (28.5)	29 (31.2)	
Rural	124 (14.4)	79 (13.7)	29 (15.0)	16 (17.2)	
Cohabitation					< 0.001
Alone	349 (40.5)	186 (32.3)	107 (55.4)	56 (60.2)	
Not alone	510 (59.2)	388 (67.4)	85 (44.1)	37 (39.8)	
Missing	3 (0.3)	2 (0.3)	1 (0.5)	0 (0)	
Marital status					< 0.001
Married	444 (51.5)	347 (60.2)	71 (36.8)	26 (28.0)	
Unmarried[b]	410 (47.6)	223 (38.7)	120 (62.2)	67 (72.0)	
Missing	8 (0.9)	6 (1.1)	2 (1.0)	0 (0)	
Working status					0.010
Working	253 (29.4)	176 (30.6)	62 (32.2)	15 (16.1)	
Not working	601 (69.7)	394 (68.4)	129 (66.8)	78 (83.9)	
Missing	8 (0.9)	6 (1.0)	2 (1.0)	0 (0)	
PSS-10	15.26 ± 3.991	14.34 ± 3.529	16.04 ± 3.750	19.30 ± 4.336	< 0.001
ULS	38.90 ± 11.282	36.29 ± 10.137	41.60 ± 10.217	49.78 ± 12.483	< 0.001
Missing	35 (4.1)	21 (3.6)	9 (4.7)	5 (5.4)	
CESD	5.21 ± 4.777	3.82 ± 3.606	6.9 ± 4.923	10.34 ± 6.086	< 0.001
Missing	18 (2.1)	10 (1.7)	7 (3.6)	1 (1.1)	
SWLS	16.74 ± 4.426	17.65 ± 4.080	15.55 ± 4.410	13.57 ± 4.514	< 0.001
Missing	7 (0.8)	4 (0.7)	2 (1.0)	1 (1.1)	

Values are presented as mean ± standard deviation or number (%).
PSS-10, Perceived Stress Scale-10; ULS, UCLA Loneliness Scale; CESD, Centre for Epidemiological Studies Depression; SWLS, Satisfaction with Life Scale.
[a]Low education level refers to an educational attainment not exceeding middle school, and a high education level indicates achievement at or above high school level.
[b]Unmarried includes single, divorced, separated, widowed.
p-values obtained by chi-square test for categorical variables and ANOVA (analysis of variance) for continuous variables.

Table 2. Adjusted odds ratio (OR) between perceived stress and frailty status

	Pre-frailty vs. robust		Frailty vs. robust	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Crude OR	1.147 (1.093, 1.204)	< 0.001	1.417 (1.322, 1.520)	< 0.001
Model-1 adjusted OR	1.143 (1.089, 1.201)	< 0.001	1.427 (1.327, 1.533)	< 0.001
Model-2 adjusted OR	1.140 (1.084, 1.199)	< 0.001	1.409 (1.308, 1.518)	< 0.001
Model-3 adjusted OR	1.022 (0.961, 1.086)	0.494	1.172 (1.071, 1.283)	< 0.001

Model-1, age and sex adjusted; Model-2, Model-1 + education, residence, cohabitation, marital status and working status adjusted; Model-3, Model-2 + UCLA Loneliness Scale (ULS), Satisfaction with Life Scale (SWLS), and Centre for Epidemiological Studies Depression (CESD) adjusted; CI, confidence interval.

tional level, living alone, being unmarried, currently working, loneliness, depression, and low life satisfaction. Although sex and residence were not significantly associated with frailty, we also considered these variables in our analysis because of their clinical significance. After adjusting for confounders, perceived stress remained associated with frailty.

Depression, anxiety, loneliness, and low life satisfaction are significantly related to frailty.[5,18-21] Furthermore, individuals with frailty have higher levels of perceived stress and stress-related symptoms, although the exact mechanism remains uncertain.[22]

Theoretically, frail older adults are more likely to deteriorate after experiencing stressful events because of decreased resilience and homeostatic reserve.[23] Unlike robust individuals, those with frailty have a lower capacity to adapt; therefore, they do not return to homeostasis and manifest functional dependency. The homeostatic function of the endocrine system such as the hypothalamic-pituitary axis is reduced during aging.[24] Thus, the pattern of cortisol secretion, an essential biomarker of stress, may be altered. Specifically, lower morning and higher evening salivary cortisol levels are associated with frailty.[25,26] The empirical observation of dysregulation may provide a plausible biological background for a decreased capacity to cope with stress.

The reported associations of psychological problems with frailty suggest the need for the proper management of difficulties to improve patient resilience.[27] The results of the present study suggest that perceived stress is an important management target. Further clinical studies are required to identify effective treatment methods.

Regarding limitations of this study, the first was measurement errors resulting from self-reported assessment methods. Second was a possible selection bias owing to the exclusion of participants with missing data or those who dropped out during the study. Third, the causal relationship between frailty and perceived stress was nuanced. Frailty itself increased perceived stress, or a bidirectional interplay might exist. Longitudinal studies are required to assess the potential long-term outcomes and causal relationships. Fourth, data regarding chronic diseases and other medical indicators were not collected. Fifth, the generalizability of the findings to broader populations was limited. Therefore, follow-up studies using data from other communities with varying psychological outcomes are warranted.

In conclusion, higher levels of perceived stress were associated with frailty in older adults. Stress management efforts may help improve frailty in this population.

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CONFLICT OF INTEREST

The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization, SHL, JS, JKC; Data curation, SU, HRS, YSK; Investigation, SU, HRS, YSK; Methodology, SHL, JKC; Supervision, JKC; Writing-original draft, SHL, JKC; Writing-review & editing, SHL, JS, JKC.

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Frailty Screening and Detection of Geriatric Syndromes in Acute Inpatient Care: Impact on Hospital Length of Stay and 30-Day Readmissions

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Background: Frailty is prevalent in acute care and is associated with negative outcomes. While a comprehensive geriatric assessment to identify geriatric syndromes is recommended after identifying frailty, more evidence is needed to support this approach in the inpatient setting. This study examined the association between frailty and geriatric syndromes and their impact on outcomes in acutely admitted older adults. **Methods:** A total of 733 individuals aged ≥65 years admitted to the General Surgery Service of a tertiary hospital were assessed for frailty using the Clinical Frailty Scale (CFS) and for geriatric syndromes using routine nursing admission assessments, including cognitive impairment, falls, incontinence, malnutrition, and poor oral health. Multinomial logistic regression and Cox regression were used to evaluate the associations between frailty and geriatric syndromes and their concomitant impact on hospital length of stay (LOS) and 30-day readmissions. **Results:** Greater frailty severity was associated with an increased likelihood of geriatric syndromes. Individuals categorized as CFS 4–6 and CFS 7–8 with concomitant geriatric syndromes had 29% and 35% increased risks of a longer LOS, respectively. CFS 4–6 was significantly associated with functional decline (relative risk ratio=1.46; 95% confidence interval [CI], 1.03–2.07) and 30-day readmission (hazare ratio=1.78; 95% CI, 1.04–3.04), whereas these associations were not significant for CFS 7–8. **Conclusions:** Geriatric syndromes in frail individuals can be identified from routine nursing assessments and represent a potential approach for targeted interventions following frailty identification. Tailored interventions may be necessary to achieve optimal outcomes at different stages of frailty. Further research is required to evaluate interventions for older adults with frailty in a wider hospital context.

Key Words: Frailty, Geriatric assessment, Syndrome, Hospitalization, Outcome assessment, Inpatients

INTRODUCTION

As the population continues to age, healthcare systems face new challenges in caring for the increasing number of frail older individuals. In acute care settings, the prevalence of frailty can range from 30% to 80%,[1,2] with frailty at admission being linked to higher risks of mortality, disability, longer hospital stays, readmissions, and higher healthcare costs.[3,4] In addition, older individuals may present with frailty-related geriatric syndromes and hospital-acquired complications such as falls, delirium, and functional decline, which can further contribute to poor patient outcomes.[5]

Guidelines recommend assessing the presence of frailty, followed by the Comprehensive Geriatric Assessment (CGA), as the best practice for frailty management.[6] While CGA remains a cornerstone in managing frailty, the available evidence on CGA centers on specific conditions in specialized wards or services such as acute care of the elderly (ACE) units or orthogeriatrics.[7-9] Additionally, many of these studies neither measured frailty status or they implemented general nutritional and physical activity interventions to reduce overall frailty levels.[10,11] Therefore, evidence presumed to be applicable for establishing acute care interventions for frail older persons is not derived from studies that stratified individuals based on their frailty status.[12] While "front door" and acute frailty units show promise in incorporating CGA principles for managing frail older persons,[13,14] further evidence is needed to support the systematic and wider use of frailty assessment and to demonstrate how frailty levels can risk-stratify and prompt identification of geriatric syndromes to guide CGA interventions.[15,16]

Therefore, this study aimed to determine the associations between frailty status and the presence of geriatric syndromes among older individuals who were acutely admitted to the hospital and to assess the associations between frailty status and hospital length of stay (LOS) and 30-day readmissions in patients with geriatric syndromes. Examining the association and impact of frailty and geriatric syndromes in hospitalized older adults may inform the development of interventions and care pathways that utilize frailty status to target older adults for CGA in the acute inpatient setting.

MATERIALS AND METHODS

Study Population

We analyzed data from patients admitted to the Department of General Surgery registered in a clinical database, between January 1, 2019, and March 31, 2019. The database was designed to assess geriatric syndromes and frailty and comprised de-identified health-related data from electronic records, including demographics, in-hospital information, comorbidities, illness severity, and routine nursing assessments. We included individuals aged ≥65 years who were admitted to the General Surgery Service of the Emergency Department. The exclusion criteria were elective or same-day admissions for planned surgical procedures. The National Healthcare Group Domain Specific Review Board (DSRB) granted ethical approval for this study (DSRB Reference No. 2022/00578). Also, this study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[17]

Data Collection

We collected baseline variables including age, sex, ethnicity, and comorbidities (weighted Charlson Comorbidity Index [CCI], a tool widely used to assess the severity of comorbidities), assigning weighted scores to 19 different comorbid conditions based on their potential to impact clinical outcomes, with scores assigned to indicate low, medium, high, and very high comorbidity burden categories.[18] We also collected data on the modified Severity of Illness Index (SII), a four-level burden of illness measure validated in the local population of older adults, with excellent inter-rater agreement and predictive validity for adverse outcomes, including hospital LOS and cost of hospitalization.[19] We assessed the outcome variables of hospital LOS and 30-day readmission following discharge from the index hospitalization.

We assessed frailty using the Clinical Frailty Scale (CFS), a global synthesis assessment tool consisting of a 9-point scale that allows classification across the frailty continuum from 1 (very fit) to 9 (terminally ill).[20] The CFS is a well-validated measure of frailty that has been shown to predict adverse outcomes in older adults, including mortality, institutionalization, and functional decline. At our institution, trained nurses routinely rate the CFS based on a previously published approach[21] in patients aged ≥65 years who are triaged as non-P1 (highest acuity) cases upon admission to the Emergency Department.

We used data from routine nursing assessment tools performed by registered nurses for all patients within 24 hours of ward admission to identify geriatric syndromes, including functional decline, recurrent falls, cognitive impairment, poor oral health, bladder or bowel incontinence, and malnutrition risk. Functional decline was defined as any change in activities of daily living (ADL) status at admission compared to the premorbid status based on a modified Katz-ADL scale consisting of feeding, dressing, bathing, toileting, transferring, and ambulation.[22] To assess recurrent falls, we used a specific item from the modified Western Health Falls Risk Assessment Tool (mWHeFRA) to identify any history of two or more falls in the past 12 months.[23] Next, we assessed cognitive impairment and bladder or bowel incontinence using specific items from the mWHeFRA. We also assessed poor oral health using the Revised Oral Assessment Guide (ROAG)[24] and malnutrition risk using the Nutritional Screening Tool (NST), a locally validated nutrition risk screening tool developed for hospitalized older adults.[25] A summary of the items used to identify geriatric syndromes is shown in Table 1.

Statistical Analysis

We described categorical variables as absolute numbers and corresponding percentages, and continuous variables as means with standard deviation or medians with interquartile range (IQR) for non-parametric data.

To analyze the association between frailty status and the presence of geriatric syndromes, we stratified the CFS levels into CFS 1–3, 4–6, and 7–8 categories. We analyzed the relationships between baseline variables and geriatric syndromes with CFS categories using one-way analysis of variance or the Kruskal–Wallis test for continuous variables and the chi-square test for categorical

Table 1. Items from routine nursing admission assessments used for geriatric syndrome screening

Domain	Tool	Items	Scoring
Functional decline	Modified Katz-ADL scale[22]	Admission and premorbid levels of functioning in the domains of ambulation, transfer, dressing, toileting, and bathing.	Domains scored as independent (I), assisted (A) or dependent (D). Functional decline defined as change from I > A, A > D or I > D in any domain.
Recurrent falls	mWHeFRA[23]	2 or more falls in 12 months prior to admission.	Yes/No
Cognitive impairment	mWHeFRA[23]	Cognitive status minimally/moderately or severely impaired.	Yes/No
Bladder or bowel incontinence	mWHeFRA[23]	Incontinence of urine and/or faeces	Yes/No
Malnutrition risk	Nutritional Screening Tool[25]	Scoring based on four items: (1) diagnosis nutritional risk level (low, moderate, high); (2) physical appearance (normal, moderately underweight, severely underweight); (3) diet intake adequacy over the past 5 days or more (normal, reduced moderately, reduced severely); and (4) unintentional weight loss over past 6 months.	Score of 4 or more indicates malnutrition risk
Poor oral health	Revised Oral Assessment Guide[24]	Eight categories: voice, lips, mucous membranes, tongue, gums, teeth/dentures, saliva, and swallowing difficulties Rated according to a score of 1 (healthy) to a score of 3 (severe problems)	Oral health risk was rated low if all categories were scored as 1, moderate if any category scored 2 and high if any category scored 3.

ADL, activities of daily living; mWHeFRA, modified Western Health Falls Risk Assessment.

variables. We then performed multinomial logistic regression to evaluate CFS levels as predictors of the presence of geriatric syndromes, both unadjusted and adjusted for age, sex, ethnicity, comorbidities, and illness severity, using CFS 1–3 as the reference group.

To determine the association between frailty and concomitant geriatric syndromes and the outcomes of LOS and 30-day readmission, we calculated hazard ratios for the time to discharge and 30-day readmission using multivariable Cox regression adjusted for age, sex, ethnicity, illness severity, and comorbidities, using the non-frail (CFS 1–3) or those without any geriatric syndromes as the reference group. The proportional hazard assumption was verified and met using Schoenfeld residuals.

To account for missing data, we conducted multiple imputations using chained equations.[26] Missing values for CFS, weighted CCI, functional decline, mWHeFRA, ROAG, and NST were imputed. We generated 30 different datasets and pooled the coefficients. As a sensitivity analysis, we also performed a complete case analysis, excluding individuals with missing values. Missing data are reported in Supplemental Table S1. Statistical significance was set at $p < 0.05$. Statistical analyses were performed using Stata version 13.0 (StataCorp LLP, College Station, TX, USA).

RESULTS

Among 750 eligible individuals admitted during the study period, 733 (97.7%) had available CFS data. The mean age of the included individuals was 77.6 ± 8.2 years, half were female and most were of Chinese ethnicity. Table 2 shows the baseline characteristics of the study population according to the CFS categories. Among the 733 included individuals, 344 (45.9%), 309 (41.2%), and 80 (10.7%) were classified as CFS 1–3, CFS 4–6, and CFS 7–8, respectively. Individuals who were frailer were older and had a greater comorbidity burden, with no differences in illness severity on admission across frailty levels.

Association of Frailty with Geriatric Syndromes

We observed an increasing frequency of geriatric syndromes with greater severity of frailty. Specifically, the proportion of individuals with functional decline on admission, recurrent falls, cognitive impairment, malnutrition risk, and poor oral health was significantly higher in those with higher levels of frailty (Fig. 1, Table 3).

In both unadjusted and adjusted multinomial logistic regression models using relative risk ratios (RRRs), we observed increased risks of detecting geriatric syndromes of recurrent falls, cognitive impairment, malnutrition, and bladder or bowel incontinence for individuals in both the CFS 4–6 and CFS 7–8 categories, using the CFS 1–3 category as the reference group (Fig. 2, Supplemental Table S2). In adjusted analyses, individuals in the CFS 4–6 category had a significantly increased risk of functional decline (RRR = 1.46; 95% confidence interval [CI], 1.03–2.07), but this increased risk was not observed in the CFS 7– 8 category. In contrast, we observed an increased risk of poor oral health for individuals in the CFS 7–8 category (RRR = 4.50; 95% CI, 2.40–8.44), but not in the CFS 4–6 category.

Table 2. Baseline characteristics of study cohort by Clinical Frailty Scale (CFS) levels

	CFS 1–3 (n = 344)	CFS 4–6 (n = 309)	CFS 7–8 (n = 80)	p-value
Age (y)	74.4 ± 7.0	80.0 ± 7.9	82.2 ± 8.9	< 0.001
Sex, female	162 (47.1)	165 (53.4)	47 (58.8)	0.094
Ethnicity				
Chinese	298 (86.6)	264 (85.4)	66 (82.5)	0.630
Malay	20 (5.8)	25 (8.1)	7 (8.8)	
Indian	16 (4.7)	15 (4.9)	6 (7.5)	
Others	10 (2.9)	5 (1.6)	1 (1.2)	
Weighted CCI				
Low	91 (26.6)	40 (13.0)	7 (8.8)	< 0.001
Medium	135 (39.5)	119 (38.6)	22 (27.5)	
High	67 (19.6)	77 (25.0)	31 (38.8)	
Very high	49 (14.3)	72 (23.4)	20 (25.0)	
Severity of illness				
Level 1	3 (0.8)	8 (2.6)	0 (0)	0.164
Level 2	237 (68.9)	215 (69.6)	48 (60.0)	
Level 3	79 (23.0)	69 (22.3)	24 (30.0)	
Level 4	25 (7.3)	17 (5.5)	8 (10.0)	

Values are presented as mean±standard deviation or number (%).
CCI, Charlson Comorbidity Index.

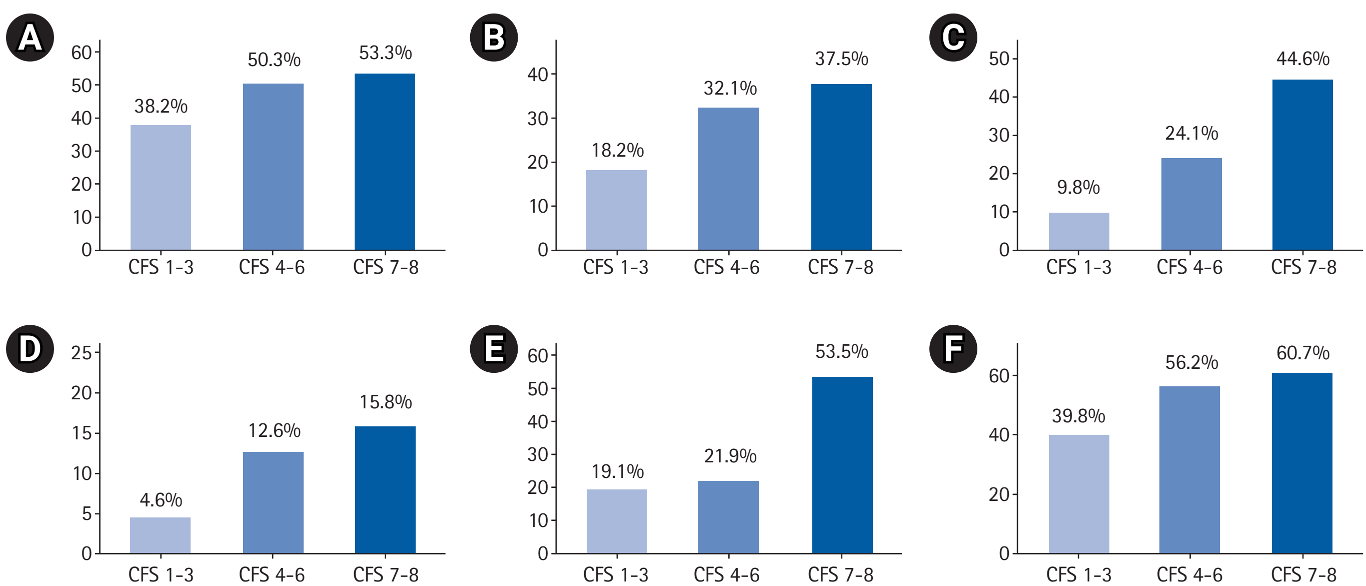

Fig. 1. Geriatric syndromes by Clinical Frailty Scale (CFS) levels: (A) functional decline, (B) recurrent falls, (C) cognitive impairment, (D) malnutrition risk, (E) poor oral health, and (F) bladder or bowel incontinence.

Impact of Frailty and Geriatric Syndromes on LOS and 30-Day Readmission Outcomes

Hospital LOS increased with greater severity of frailty, with median OS increasing from 5.9 days (IQR 2–6), 8.1 days (IQR 2– 9), and 8.3 days (IQR 3–8.5) across the CFS 1–3, CFS 4–6, and CFS 7–8 categories, respectively. In multivariate Cox regression analysis, increasing frailty with any concomitant geriatric syndrome was associated with a lower probability of discharge. Specifically, individuals in the mild-to-moderately frail and severely frail categories showed 29% and 35% reductions in the probability of discharge at any given LOS, respectively. The 30-day readmission rates were 11.6% (40 patients), 17.2% (53 patients), and 18.8% (15 patients)

Table 3. Comparison of geriatric syndromes by Clinical Frailty Scale (CFS) levels

	CFS 1–3 (n=344)	CFS 4–6 (n=309)	CFS 7–8 (n=80)	p-value
Functional decline				
Functional decline in any domain	124 (38.2)	151 (50.3)	41 (53.3)	0.003
Number of domains	1.7±2.4	2.2±2.4	2.8±2.9	0.006
Recurrent falls				
2 or more falls in the past 12 months	58 (18.2)	93 (32.1)	21 (37.5)	<0.001
Cognitive impairment				
mWHeFRA cognitive status impaired	31 (9.8)	70 (24.1)	25 (44.6)	<0.001
Malnutrition risk				
NST total	1.2±1.3	1.7±1.5	2.1±1.9	<0.001
NST at risk	15 (4.6)	38 (12.6)	12 (15.8)	<0.001
Poor oral health				
ROAG risk categories				
Low risk	127 (80.9)	178 (78.1)	33 (46.5)	<0.001
Moderate risk	28 (17.8)	44 (19.3)	24 (33.8)	
High risk	2 (1.3)	6 (2.6)	14 (19.7)	
ROAG moderate to high risk	30 (19.1)	50 (21.9)	38 (53.5)	<0.001
Bladder or bowel incontinence				
mWHeFRA continence problems	126 (39.8)	163 (56.2)	34 (60.7)	<0.001

Values are presented as number (%) or mean±standard deviation.
mWHeFRA, modified Western Health Falls Risk Assessment; NST, Nutritional Screening Tool; ROAG, Revised Oral Assessment Guide.

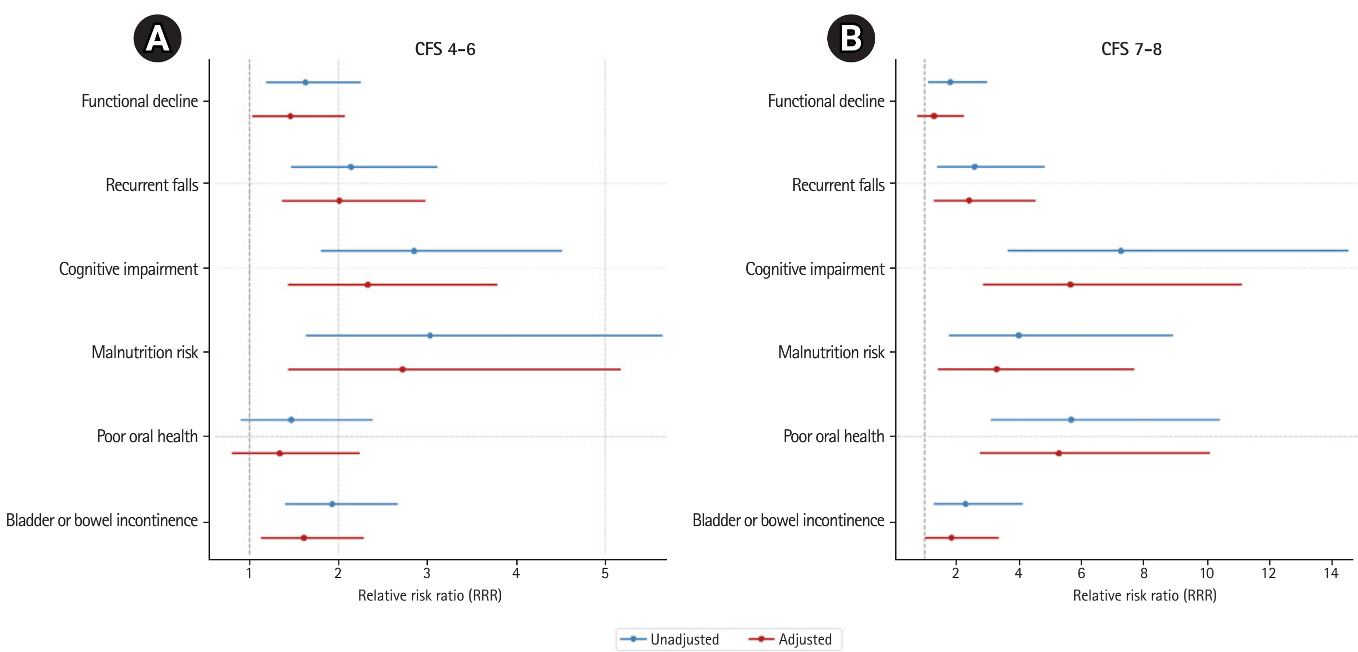

Fig. 2. Multinomial logistic regression for the association between Clinical Frailty Scale (CFS) levels and geriatric syndromes: (A) CFS 4–6 and (B) CFS 7–8.

across CFS 1–3, CFS 4–6, and CFS 7–8 categories respectively. In multivariable Cox regression analysis, the hazards of 30-day readmission increased for individuals in the CFS 4–6 category, but not for those in the CFS 7–8 category (Table 4). In the sensitivity analyses, the associations determined through the complete case analysis demonstrated similar results to those obtained using the imputed data (Supplemental Tables S3, S4).

Table 4. Cox proportional hazards models: associations of frailty levels and any concomitant geriatric syndrome with hospital length of stay and 30-day readmissions (imputed data)[a]

Outcomes	HR (95% CI)	p-value
Hospital length of stay[b]		
CFS 1–3 or no geriatric syndromes present	1 (reference)	
CFS 4–6 + any geriatric syndrome	0.71 (0.59–0.86)	< 0.001
CFS 7–8 + any geriatric syndrome	0.65 (0.47–0.90)	0.010
30-day readmissions		
CFS 1–3 or no geriatric syndromes present	1 (reference)	
CFS 4–6 + any geriatric syndrome	1.78 (1.04–3.04)	0.036
CFS 7–8 + any geriatric syndrome	1.57 (0.68–3.67)	0.290

CFS, Clinical Frailty Scale; HR, hazard ratio; CI, confidence interval.
[a]Models adjusted for age, sex, ethnicity, comorbidities, and severity of illness.
[b]A HR less than 1 indicates a lower hazard of discharge at any given length of stay.

DISCUSSION

This study investigated the relationship between frailty and geriatric syndromes in acutely admitted older adults and their impact on hospital LOS and 30-day readmission. The results showed that frailty was associated with a greater likelihood of geriatric syndromes, including functional decline, recurrent falls, cognitive impairment, malnutrition risk, incontinence, and poor oral health. However, severe frailty (CFS 7–8) was not associated with functional decline. Additionally, greater frailty severity in the presence of geriatric syndromes was linked to increased LOS, but increased risk of 30-day readmissions was only significantly associated with mild-to-moderate frailty (CFS 4–6), and not with severe frailty. Overall, our results underscore the potential of frailty identification in flagging the possible presence of geriatric syndromes, and that frailty with concomitant geriatric syndromes is associated with poorer outcomes, with these outcomes varying depending on the level of frailty.

While CGA-based multidisciplinary care in inpatient settings has demonstrated beneficial effects, outcomes vary depending on the clinical setting and model adopted.[9] Positive outcomes include an increased likelihood of individuals being alive and in their own homes at follow-up and reduced institutionalization rates. However, the effects on mortality, dependence, and healthcare costs have been inconsistent.[27] In another meta-analysis, CGA was effective in improving quality of life and reducing caregiver burden but did not affect the hospital LOS.[28] Moreover, evidence for the benefits of CGA is setting-specific, differing by ward- or team-based models of care as well as by specific conditions such as oncology[29] or perioperative care,[30] while most studies utilize age-based inclusion criteria.[9] Although chronological age and specific conditions have traditionally guided clinical decision-making, our findings suggest that frailty is an indicator of an elevated risk of poor health outcomes in the inpatient setting. With the identification of frailty, emerging evidence supports the introduction of structured exercise programs and nutritional modifications targeting hospitalized frail older adults.[31]

The CFS was originally introduced as a means of summarizing the results of the CGA, which is typically conducted in specialized geriatrician-led settings. Considering the increasing number of older adults accessing healthcare services, frailty screening is being used as a risk stratification approach in wider hospital settings.[32] This approach uses frailty level as a triage tool to recognize geriatric syndromes in at-risk individuals and trigger referrals for CGA and its associated interventions.[33,34] Additionally, integrating frailty assessments into routine care adds value by guiding clinicians to develop more rational, person-centered care plans that recognize under-detected geriatric syndromes, and prioritize achieving functional goals beyond treating individual diseases alone.[35,36]

Our results revealed that, with an increase in frailty levels across the three CFS categories, the likelihood of detecting geriatric syndromes also increased. A notable exception was in the domain of functional decline, where we observed a significant increase in the risk of functional decline among individuals in the mild-to-moderately frail (CFS 4–6) category but not for those in the severely frail (CFS 7–8) category. This finding could be due to a higher baseline level of functional impairment in patients with more severe frailty upon admission, making changes in functionality during hospitalization less discernible.

Previous studies have also emphasized the predictive utility of individual and combined indicators of geriatric syndromes for healthcare utilization.[37,38] Frailty, dementia, and acute confusion predict prolonged LOS, delayed discharge, institutionalization, and 30-day readmission.[5] In a systematic review and meta-analysis, greater frailty severity was common in older patients with unplanned hospital admissions and was associated with increased risks, including mortality and longer LOS. However, moderate-to-severe frailty levels were inconsistently related to 30-day readmissions,[39] an observation similar to that in our study, in which the presence of geriatric syndromes did not fully account for 30-day readmissions in severely frail patients. While few studies have focused on the readmission risk in severely frail individuals, potentially modifiable risk factors such as medication management and care coordination may influence outcomes in these individuals.[40]

Our finding of a lower likelihood of detecting bladder or bowel incontinence in severely frail individuals than in mild-to-moderately frail individuals may be explained by specific items in the mWHeFRA continence domain, where participants with indwelling urinary catheters are scored as zero, denoting a low risk of incontinence. Moreover, the mWHeFRA ascribes higher risk scores to individuals with urinary frequency, urgency, and nocturia, which may not be apparent in severely frail, functionally impaired patients. These findings indicate the need to refine or utilize screening questionnaires to more accurately detect geriatric syndromes. Nevertheless, our results highlight the potential for using frailty levels to predict the likelihood of geriatric syndromes, with the potential to tailor interventions to meet individual needs.[41,42] For example, at advanced stages of frailty, strategies to promote advanced care planning[43] or pain and symptom management may be more relevant than focusing on geriatric syndromes alone.[44]

Our findings also highlight the potential of utilizing routinely collected admission information to screen for geriatric syndromes rather than introducing new tools that may require additional resources, expertise, and time.[45] Although not all the items used to identify potential geriatric syndromes were validated as syndrome-specific screening tools, our findings indicate that such an approach may still be beneficial for identifying these geriatric conditions. Utilizing existing data sources may avoid the introduction of additional processes into the healthcare system and minimize the burden on healthcare providers while enabling the extension of geriatric care beyond specialized geriatrician-led settings and facilitating the implementation of routine geriatric screening in hospitals.[46] Nevertheless, further studies are necessary to confirm the presence or absence of geriatric syndromes using this approach.

The strengths of this study include the assessment of frailty and geriatric syndromes in hospitalized older adults using standardized measures. In addition, we compared the results from multiple imputations and complete case analyses to address missing data. However, this study has several limitations. First, we identified geriatric syndromes using routinely collected data from nursing admission assessments, which may not have captured all the relevant syndromes. CGA is a multidimensional, interdisciplinary diagnostic process that evaluates an older adult's medical, functional, cognitive, and psychosocial status. Other domains, including social need assessments and discharge planning, are required to develop and implement coordinated care plans that address these issues. Second, although we identified geriatric syndromes through screening tools, confirmation of the presence of geriatric syndromes by a geriatrician or formal diagnosis was not available. Further studies exploring the addition of screening for other CGA domains, such as polypharmacy, sensory impairment, and confirmatory diagnosis of syndromes, such as dementia or delirium, are needed. Third, information on frailty and geriatric syndromes was obtained on admission and within 24 hours of admission; thus, we were unable to account for geriatric syndromes that could have developed during admission. As our database was primarily structured to collect data on geriatric syndromes and frailty, information on other variables such as surgical diagnoses, type of surgery, and complications was not available. While our study did not demonstrate differences in the severity of illness at admission between the CFS groups, further studies including more details on intervening events for the analysis of longitudinal outcomes are recommended. Finally, these results cannot be generalized to other inpatient settings and disciplines.

Despite these limitations, our findings suggest the potential role of routine frailty assessment in identifying geriatric syndromes in acute inpatient settings. Our findings also indicate that the presence of geriatric syndromes in patients with severe frailty may not affect 30-day readmission, suggesting that other factors may influence this outcome. Additionally, routine, existing nursing admission assessments for geriatric syndrome screening could be a practical approach to facilitate the extension of geriatric care and trigger CGA beyond specialized geriatrician-led settings to reach older adults across hospitals. Further research should focus on developing and implementing feasible CGA interventions to address the complex needs of frail older adults in acute-care settings.

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CONFLICT OF INTEREST
The researchers claim no conflicts of interest.

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None.

AUTHOR CONTRIBUTIONS
Conceptualization, JC; Data curation, JC, JQC, KKK, JKF; Investigation, JC; Methodology, JC, SYC; Supervision, HNT; Writing-original draft, JC; Writing-review & editing, JC, CL, SYC, HNT.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4235/agmr.23.0124.

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Factors which Influence the Frequency of Cognitive Assessment in the Emergency Department

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Background: The practice of safe emergency medicine requires accurate and adequate assessments. However, screening for cognitive deficits is not performed regularly in the emergency department (ED). This study aimed to determine factors influencing the frequency of cognitive testing by ED doctors. **Methods:** This study included all doctors working in the EDs of three teaching hospitals. A 17-item online survey instrument that collected information on sex, experience, perceived prevalence, perception, and practice of cognitive assessment was distributed through electronic mail and data messaging services. **Results:** Of the 210 participants, 72 were male. The estimated mean with standard deviation prevalence of cognitive impairment in older patients in the ED was 39.5%±19.7%. Among the participating ED doctors, 75.8% performed cognitive testing up to 10% of the time. Moreover, the participants ranked cognitive impairment the lowest compared to the other four chronic conditions in terms of its impact on hospitalization outcomes. Multiple linear regression revealed that the doctors' perceptions of the responsible personnel and the importance of cognitive testing, as well as their lack of expertise, were independently associated with the frequency of testing. **Conclusion:** Lack of expertise, perception of the importance of cognitive testing, and lack of consensus on which discipline is responsible for performing cognitive testing in older patients in the ED were the limiting factors in performing cognitive testing in the ED. Improving perception and awareness of the importance of cognitive assessment as a screening tool could improve the detection and overall management of older patients.

Key Words: Aged, Delirium, Dementia, Cognitive dysfunction, Emergency medicine

INTRODUCTION

With advancements in health services, the population of older adults is growing rapidly in many developing countries. Many people aged ≥65 years enjoy relatively good health. However, these individuals are more likely to have multiple chronic diseases than any other age group, predisposing them to falls, functional decline, vertigo, syncope, urinary incontinence, delirium, and dementia.[1)]

Cognitive impairment is prevalent among older adult patients in emergency departments (EDs), with reported prevalence rates of 10% to 16%.[2-4)] However, the curricula of medical courses do not emphasize brief mental status assessments, which has resulted in the inadequate evaluation of older adult patients.[5)] Cognitive assessment represents one of three significant gaps in the quality of care for geriatrics.[6)] Screening and measurement instruments to evaluate the mental functions of older patients are often deemed unsuitable for busy and crowded ED settings due to lack of time, staff, space, possible unfamiliarity, or lack of knowledge of the various cognitive screening tools available. As such, cognitive impairment in many patients is overlooked despite its significant influence on patient management and prognosis.[7)]

Few studies have addressed the relationship between the perception and knowledge of cognitive impairment and cognitive screening in the clinical environment. Therefore, this study examined the relationship between cognitive assessment frequency and ED doctors' perceptions and attitudes regarding cognitive impairment. The findings of this study will inform future efforts to implement cognitive screening in the ED, leading to enhanced quality of care among older adults presenting in this setting.

MATERIALS AND METHODS

Study Design and Setting

This study applied a cross-sectional survey based on self-administered questionnaires distributed in the EDs of three Malaysian teaching hospitals: University of Malaya Medical Center, Universiti Kebangsaan Malaysia Medical Center, and Hospital Universiti Sains Malaysia. Ethical approval was obtained from the Medical Research Ethics Committee of the University Malaya Medical Center (MREC ID No. 201761-5299). Data were collected over 6 months. All ED doctors in these hospitals were invited to participate in the survey. Doctors from other departments who visited the ED to attend referrals were excluded. Informed consent was waived. This study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[8)]

Data Collection

This online survey utilized Google Forms (Google, Mountain View, CA, USA). The survey link was disseminated through electronic mail as well as the data messaging services Telegram and WhatsApp to potential respondents from the identified teaching hospitals. Five reminders were sent to non-responders.

Study Instrument

The study instrument comprised a set of questionnaires from a previous study on the knowledge, attitude, and cognitive assessment skills of older doctors in the ED.[7)] The questionnaire contained 17 items that collected information on clinical experience, sex, level of exposure to older patients, perception and attitude of medical practitioners towards cognitive assessment in the ED, and factors associated with good/bad frequency of cognitive assessment performance in the ED. The survey instrument is included in Supplementary Materials.

Perceptions and attitudes

The respondents were asked to estimate the overall prevalence of cognitive impairment in older patients attending their ED and how frequently they screened patients for this impairment. The doctors were then asked to provide a score out of 10 for conditions that impacted mortality, morbidity, and chances of readmission, where a score of 10 represented the highest level of impact.

Factors influencing cognitive testing

We asked the respondents to indicate the significant factors that limited their ability to perform formal cognitive screening in older patients in the ED, whether they thought it was important and necessary to perform cognitive screening as part of the routine assessment of all older patients in the ED, what the limitations were, and who they felt should perform this assessment. The respondents were asked if they perceived an assessment of orientation as an assessment of cognition, and whether they were familiar with several established cognitive screening tools.

Statistical Analysis

We used OpenEpi Software to calculate a sample size of 128, with a population size of 210 and an anticipated frequency of 30% based on the estimated prevalence of cognitive impairment among older adult patients in the ED reported in several studies.[9)]

Data analysis was conducted using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics are expressed as means with standard deviations or frequencies with percentages for continuous and categorical data, respectively. We determined the statistical significance of differences between groups using the Mann-Whitney U test and independent t-tests for non-parametric and parametric continuous variables, and the chi-square test for categorical variables, respectively. We then conducted multiple linear regression to identify the factors that independently influenced the likelihood of performing cognitive assessments. The variables identified as significantly different from the baseline comparison were included in the multiple linear regression model in a backward stepwise manner.

RESULTS

Respondent Characteristics

Among 210 potential respondents, 128 (61%) completed the online survey instrument, 72 (56%) of whom were men. Of these, 85 (66%) had at least 3 months' exposure to geriatric medicine and 120 (94%) had at least 3 months' experience in the ED, with a response rate of 58.18%. Ninety (70%) had a geriatric medical unit in the hospital. Among the respondents, 10 (8%) were emergency physicians, 17 (13%) were registrars, 31 (24%) were medical officers with > 5 years of experience, and 70 (55%) were medical officers with < 5 years of experience.

Perceptions and Attitudes

Thirty-one (24%) respondents believed that > 60% of older patients in the ED were cognitively impaired. The mean ± standard deviation estimated prevalence of cognitive impairment in older adults among patients in the ED was 40 ± 20%, with 19% estimating a prevalence of ≤ 20%. Sixty-five (51%) respondents felt it was important to perform cognitive screenings in the ED, although 75 (59%) did not feel a simple assessment of orientation to person, place, and time would sufficiently assess cognition. In this study, 102 (80%) and 25 (20%) respondents felt that cognitive assessments should be conducted by the on-call medical team and ED doctors, respectively.

Frequency of Cognitive Screening

Ninety-seven (75.8%) respondents performed cognitive testing up to 10% of the time they assessed older patients in the ED. Less than 5% of the respondents performed more frequent cognitive assessments. Those who perceived cognitive testing in the ED as important ($p = 0.001$) and that it was the doctor's responsibility to conduct cognitive screening in the ED ($p < 0.001$) were more likely to perform cognitive testing in the ED (Table 1).

In this study, 106 (83%) respondents identified a lack of time as a factor limiting cognitive testing in the ED, whereas 97 (76%) reported a lack of expertise. Additionally, 66 (52%) reported a lack of availability of screening tools, whereas 42 (33%) responded cited environmental factors and noise levels. Among screening instruments, 102 (95%) respondents had heard of the Mini-Mental State Examination (MMSE) and 76 (59%) had used it for cognitive screening, whereas 59 (46%) and 18 (14%) had heard of or used the Abbreviated Mental Test score, six-item screener, Mini-Cog, CLOX test, short-blessed test, Ottawa 3DY, and AD8 dementia screen. A lack of expertise was significantly associated with a lower frequency of testing (14.3% ± 14.5% vs. 22.7% ± 20.7%; $p = 0.012$). Overall, the respondents ranked cognitive impairment as the lowest among the four other medical conditions in terms of its impact on patient mortality, morbidity, and readmission risk (Table 2).

Multiple Linear Regression

The results of the multiple linear regression analysis (Table 3) revealed that the opinions of the person responsible for conducting the cognitive assessment, the importance of performing cognitive testing in the ED, and the presence of expertise were independent-

Table 1. Respondent characteristics and factors influencing the frequency of performing cognitive assessment

	n (%)	Frequency of cognitive testing (%)	p-value
Sex			0.261
Male	72 (56)	17.8 ± 19.1	
Female	56 (44)	14.5 ± 12.2	
Seniority			0.396
ED specialist	10 (8)	21.5 ± 23.6	
Registrar	17 (13)	20.0 ± 24.5	
Medical officer, > 5 y	31 (24)	17.3 ± 15.2	
Medical officer, ≤ 5 y	70 (55)	14.3 ± 13.3	
3-month exposure to geriatric medicine			0.354
Yes	85 (66)	17.3 ± 18.2	
No	43 (34)	14.4 ± 12.5	
Geriatric unit			0.240
Yes	90 (70)	17.4 ± 18.2	
No	38 (30)	13.7 ± 11.4	
Cognitive testing is important			0.001
Yes	65 (51)	20.8 ± 21.5	
No	63 (49)	11.7 ± 5.96	
Testing for orientation is sufficient			0.446
Yes	53 (41)	15.0 ± 16.5	
No	75 (59)	17.3 ± 16.5	
Responsible personnel			< 0.001
ED doctor	25 (20)	27.2 ± 27.9	
Medical team	102 (80)	13.7 ± 11.0	
Lack of expertise, no formal training			0.012
Yes	97 (76)	14.3 ± 14.4	
No	31 (24)	22.7 ± 20.7	
Availability of appropriate tool			0.438
Yes	66 (52)	15.2 ± 16.6	
No	62 (48)	17.5 ± 16.4	
No appropriate environment			0.616
Yes	42 (33)	17.4 ± 19.6	
No	86 (67)	15.8 ± 14.8	
Noise levels			0.814
Yes	42 (33)	15.8 ± 18.8	
No	86 (67)	16.6 ± 15.4	
Time constraints			0.233
Yes	106 (83)	17.1 ± 17.4	
No	22 (17)	12.5 ± 10.4	
Aware of other tools			0.192
Yes	59 (46)	18.4 ± 19.4	
No	69 (54)	14.6 ± 13.4	
Used other tools			0.052
Yes	18 (14)	23.3 ± 22.9	
No	110 (86)	15.2 ± 15.0	

Values are presented as number (%) or mean±standard deviation.
ED, emergency department.

Table 2. Ranking of the importance of chronic conditions

Rank in order of importance	Chronic condition	Value[a]
1	Heart failure	3.48 ± 0.580
2	Respiratory failure	3.36 ± 0.661
3	Kidney failure	3.32 ± 0.651
4	Liver failure	2.56 ± 1.085
5	Cognitive impairment/dementia	2.30 ± 1.097

Values are presented as mean±standard deviation.
[a] Mean score out of 5, where a higher score indicates greater importance.

Table 3. Multiple linear regression model for factors associated with the frequency of cognitive testing in the ED

Variable	Mean difference	95% CI	p-value
Lack of expertise	-6.84	-13.2, -0.56	0.033
ED doctor's role	11.21	4.28, 18.14	0.002
Cognitive testing in the ED is important	6.15	0.57, 11.72	0.031
Constant	25.90	9.79, 22.70	< 0.001

R=0.424, R^2=0.18.
ED, emergency department; CI, confidence interval

ly associated with the frequency of cognitive testing. This model explained 18% of the variation in the frequency of cognitive testing in the ED in the study sample ($R^2 = 0.18$).

DISCUSSION

The results of this study revealed that the frequency of cognitive testing in the EDs of three teaching hospitals in West Malaysia was influenced by previous exposure to geriatric medicine, perception of the importance of cognitive testing in the ED, and attitude towards the responsibility of conducting this testing. Cognitive impairment was ranked the lowest among the conditions that influenced mortality and morbidity in hospitals, and few of the responding doctors had heard of cognitive assessment tools other than the MMSE. The respondents felt that time constraints and a lack of expertise and training were the most important factors limiting cognitive assessment in the ED.

A recent study conducted among older medical inpatients at one of the study centers reported a 27% prevalence of cognitive impairment based on the confusion assessment method,[10] a rate lower than the estimated prevalence offered by the respondents. The variation in responses was large, with 25% of respondents overestimating the prevalence as > 60%. Despite this overestimation, most respondents conducted cognitive screening < 10% of the time, a rate lower than that in a previous study on the frequency of cognitive testing in the ED on different continents.[7] This practice may have been influenced by the perception of ED doctors regarding their competency in identifying cognitive impairment in older patients as well as the low priority assigned to cognitive assessment as an organ failure. Overestimation of the prevalence of cognitive impairment suggests an element of preconceived bias or ageism among respondents. This leads to a perception of the limited value of screening and a tendency to ignore older adults in communication and decision-making.

The doctors surveyed in this study lacked familiarity with brief cognitive screening instruments in the ED, despite the availability of several validated brief screening tools designed for the ED setting.[11,12] Since there remains no clear consensus in the literature favoring one specific cognitive screening tool over another, EDs may adopt any single screening tool and incorporate it into practice as a routine evaluation of older patients in the ED. The implementation of any brief cognitive screening tool in ED practices and workflows will require the department to ensure adequate staff training in administering and interpreting screening assessments. The Abbreviated Mental Test-4 was introduced as a screening tool for cognition in older patients in the ED in the United Kingdom.[13] These good practices could be emulated, and cognitive assessment should be an integral part of the routine clinical workup for all older adult patients in the ED. The frequency of cognitive testing and detection of cognitive impairment may be improved by correcting pre-existing perception biases and ensuring proper training among ED doctors.

Time constraints in the ED due to high patient turnover are a major factor in performing cognitive testing. Adequate doctor training may aid in the selection of appropriate tools and efficiency in conducting cognitive testing, which will reduce the length of time required to administer these tools. Potential environmental issues related to noise levels can be addressed with future planning of the physical infrastructure in terms of ED design and layout. These changes will also enhance privacy and reduce the risk of delirium among older persons in the ED.[14] The recognition of delirium is the first step towards its effective prevention and treatment. Effective strategies to reduce the potential for developing cognitive impairment postoperatively have been identified, which further emphasizes the need to detect delirium as it is likely to substantially affect patient outcomes.[15]

This study has several limitations. For instance, this study included only teaching hospitals in West Malaysia, although the response rate was superior to that of online surveys conducted among physicians.[16] Additionally, a larger survey engaging the help of regulatory bodies or medical societies may help with the national inclusion of other hospital EDs. Future studies are needed to identify effective strategies to enhance cognitive screening in the ED and evaluate interventions to prevent and manage delirium in

ED settings.

In conclusion, the frequency of cognitive assessment in the ED is associated with the perception of its importance, the role of the ED doctor, and the ED doctor's expertise. Measures to change the ED doctors' perception of the importance of cognitive assessments as part of essential patient care, instituting training to enhance expertise, and providing a suitable screening tool may result in a better cognitive assessment performance in the ED.

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CONFLICT OF INTEREST

The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization, MIZ, TMP; Data curation, SAS; Investigation, SAS; Methodology, MIZ, TMP, AZ; Project administration, SAS, MIZ; Supervision, MIZ, TMP, AZ; Writing-original draft, SAS, MIZ, TMP; Writing-review & editing, MIZ, SAS, TMP, MA.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4235/agmr.23.0150.

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Meta-Analysis on the Association between Echo Intensity, Muscle Strength, and Physical Function in Older Individuals

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Background: The use of ultrasonographic echo intensity (EI) to evaluate skeletal muscle quality and its effects on strength, explosive power, and physical function (PF) in older individuals remains unclear. This meta-analysis evaluated the associations among EI, muscle strength (MS), and PF in older individuals. **Methods:** We conducted a systematic search of the PubMed, Embase, Web of Science, SPORT Discus, and CINAHL databases through October 2022 to identify primary studies examining the association between EI and MS/PF. Effect sizes were computed using a random-effects model and presented using forest plots. Pearson correlation coefficient (r) and I^2 statistics were used to measure heterogeneity. **Results:** This meta-analysis included 24 patients. EI demonstrated a negative association with maximal strength (r=-0.351; 95% confidence interval [CI], -0.411 to -0.288; p<0.001) and explosive power (r=-0.342; 95% CI, -0.517 to -0.139; p=0.001) in older individuals. Handgrip strength also showed a significant negative correlation with EI (r=-0.361; 95% CI, -0.463 to -0.249; p<0.001). However, we observed only a small and non-significant negative association between EI and gait speed (r=-0.003; 95% CI, -0.083 to -0.077; p=0.943), and a weak non-significant correlation with the chair stand test (r=0.072; 95% CI, -0.045 to 0.187; p=0.227). **Conclusion:** Increased EI was associated with lower strength and power but not with gait speed or chair test performance in older individuals. Further large-sample studies with long-term follow-up are needed to improve frailty prediction and risk assessment in this population.

Key Words: Ultrasonography, Muscle strength, Physical functional performance, Aging

INTRODUCTION

Aging results in a decline in the quantity and quality of human skeletal muscle, a condition known as sarcopenia.[1] Sarcopenia significantly affects the quality of life and independence of elderly adults by limiting their ability to perform daily functional activities such as standing up from a chair and walking, as well as increasing the risk of falls in this population.[2,3] Ultrasound imaging is a non-invasive and safe method that can be used to assess skeletal muscle quality. Among these qualities, echo intensity (EI) is an important indicator of the proportion of noncontractile elements during aging. EI reflects the infiltration of fatty and fibrous tissue of the muscle and is quantified by examining the darkness of interest in selected areas, in which black and white indicate high and low muscle quality, respectively.[4,5] The loss in muscle strength associated with skeletal muscle wastage and sarcopenia may arise from decreased muscle quality, with lower extremity strength declining more markedly than that of the upper extremities during aging, ranging from 10% to 15% loss of leg strength per decade until the age of 70 years, followed by a more rapid loss, ranging from 25% to 40% per decade.[6,7]

Previous cross-sectional studies have reported significant associations between muscle quality measured using EI in the lower extremities of older adults. For instance, EI transverse images of older subjects were correlated with knee extension isometric strength (r = -0.40),[8] isometric strength (r = -0.62),[9] and rate of force/torque development (r = -0.39).[10] In addition, quadriceps EI was negatively correlated with handgrip strength in older adults (r = -0.386).[11] Interestingly, the connection of EI with muscle strength is independent of endurance and muscle size.[8,9] Meanwhile, evidence has shown an inverse relationship between adiposity-to-muscle ratio assessed by ultrasound EI and functional performance in older adults, with lower EI values associated with better performance. EI is also the strongest predictor of the 30-second sit-to-stand test (30SS) (r = -0.56).[12] Furthermore, EI is associated with gait-related performance, considering the role of the lower extremity muscles in locomotion. The EI of the vastus lateralis was weakly correlated with usual gait speed (USG; r = -0.05) and maximal gait speed (MGS; r = -0.11),[13] while a moderate correlation was reported between the EI of the rectus femoris and USG (r = -0.46).[14]

Although the available data indicate that the infiltration of non-contractile elements may affect muscle strength and functional performance in older individuals, no meta-analysis has explored the correlation between lateral EI images and muscle strength or physical function in this population. Therefore, this systematic meta-analysis investigated the associations among EI (representing muscle quality), muscle strength, and physical function in older individuals.

MATERIALS AND METHODS

We conducted this review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[15] The PROSPERO International Prospective Register of Systematic Reviews (CRD42023387441) registered the review protocol, to which we adhered without any deviations.

Search Strategy

We employed a systematic search strategy using Boolean operators in the PubMed, Embase, Web of Science, SPORTDiscus, and CINAHL databases through October 2022. We modified the keywords and Boolean operators according to each database's search strategy and restricted the search to studies involving humans, written in English, and reported in peer-reviewed journals. The search strategy is presented in Supplementary Table S1.

Selection Criteria

Studies meeting the following criteria were included: (1) healthy community residents aged ≥60 years without major neurological and musculoskeletal disorders; (2) muscle mass testing using EI and reporting at least one direct assessment of muscle strength or physical function performance; (3) observational studies, including cross-sectional studies, cohort studies, and a few case-control studies; (4) published studies in English.

Articles were excluded if (1) the participants were currently on medication or had an injury that limited their physical activity and independence in daily living; (2) the study was conducted in an animal model; (3) the participants received interventions other than usual care or placebo, or randomized controlled trials; (4) the results were partially unable to extract the correlation coefficient; (5) reviews, abstracts, case reports, or duplicate published articles; and (6) non-English articles.

Two independent researchers screened the titles and abstracts of all studies based on the inclusion and exclusion criteria and then reviewed the full text of the remaining studies. Disagreements were resolved through discussion.

Data Extraction

The data extraction process involved coding the author information, publication year, and population characteristics (sample size, sex, and mean age). The correlation coefficient (r) or standardized beta coefficient between EI and two continuous muscle strength or physical function variables was extracted. The test modality/results and the results of the muscle strength assessments and physical function tests were also coded. Muscle strength was categorized into lower extremity maximum strength (i.e., maximal voluntary force/torque of the force-/torque-time curve [MVC]), explosive force (i.e., rate of force/torque development [RFD/RTD]), and handgrip strength (assessed with a handheld dynamometer [HGS]), while physical function was divided into gait speed and mobility. Gait speed (e.g., UGS and maximum gait speed [MGS]), chair stand test (e.g., 30SS), five repetitions of the sit-to-stand test (5STS), and Timed Up-and-Go (TUG) test were used to classify physical function. If no correlation was reported, the authors were contacted for the missing information. If the author did not respond, the study was excluded from the analysis.

Data Quality

We assessed the risk of bias in the included studies using the Joanna Briggs Institute Analytic Cross-sectional Study Quality Checklist (Supplementary Table S2). We evaluated the methodological quality of the selected studies according to eight items that assessed the inclusion criteria, study participants and settings, criteria for condition measurement, validity and reliability of exposure and outcome measures, confounding factors and resolution strategies, and statistical analysis. Two authors evaluated each item, which was rated as “yes,” “no,” “unclear,” or “not applicable.”

Statistical Analysis

We conducted the meta-analysis using Comprehensive Meta-Analysis (CMA), version 3.3.070, to analyze the Pearson product-moment correlation coefficients (r) obtained from the included studies. The r-values were converted into normally distributed variables (z-transformed Rz-values) using Fisher z-transformation according to the following formula[16]:

$$z' = 0.5\,[\ln(1+r) - \ln(1-r)].$$

where ln is the natural logarithm.

We converted the beta coefficient (β) to an r value using the following formula[17]:

$$r = 0.98\beta + 0.05\lambda,\ \ (\text{if } \beta \geq 0,\ \lambda = 1;\ \beta < 0,\ \lambda = 0).$$

We calculated the weights of the studies based on standard errors (SE) using the following formula:

$$SE = 1/\sqrt{(N-3)},$$

where N is the sample size.

We selected a random-effects model for the meta-analysis.

Correlations (positive or negative) were classified as small ($r < 0.3$), medium ($0.3 \leq r \leq 0.5$), or large ($r > 0.5$).[18] We generated forest plots to display studies with 95% confidence intervals (CI) and the combined coefficients. The Rz values were reverse-converted to r values to classify and interpret relevant sizes. We evaluated the heterogeneity of the results between studies using the I^2 index, where $I^2 \leq 25\%$ indicated low heterogeneity, $I^2 > 25\%$ and $I^2 < 75\%$ indicated moderate heterogeneity, and $I^2 \geq 75\%$ indicated high heterogeneity.[19] Finally, we used funnel plots to investigate the possibility of publication bias.

RESULTS

Search Characteristics

A total of 824 articles were retrieved from the initial database search through October 2022. After removing duplicates ($n = 327$) and 338 articles based on the title or abstract, 159 articles remained and were assessed for eligibility. Finally, 24 articles were included in the meta-analysis (Fig. 1). A total of 2,501 people were included in this review, and the mean age was 71.3 ± 5.5 years. The sample sizes ranged from 12 to 1,239. Supplementary Table S3 details the baseline characteristics of the included studies.

Association between EI and Muscle Strength

Sixteen studies (2,009 participants) analyzed the association between EI and maximal strength in healthy older adults.[8,9,11,13,20-30] The results revealed a significant moderate correlation negative between EI and maximum strength ($r = -0.35$; 95% CI, -0.41 to -0.28; $p < 0.001$; $I^2 = 34.94$). Four studies (190 participants) analyzing the association between EI and explosive power in healthy older adults,[11,22,28,31] showed a significant moderate negative correlation between EI and explosive power ($r = -0.34$; 95% CI, -0.51 to -0.13; $p = 0.001$; $I^2 = 47.70$). Three studies (261 participants) showed a moderate negative correlation between EI and handgrip strength[11,32,33] ($r = -0.36$; 95% CI, -0.46 to -0.24; $p < 0.001$; $I^2 = 0.000$) (Fig. 2).

Association between EI and Physical Function

Gait speed

Fourteen studies (involving 641 participants) investigated the association between EI and gait speed.[11,13,14,21,22,33-35] The combined effect size for EI and gait speed was $r = 0.00$ (95% CI, -0.08 to

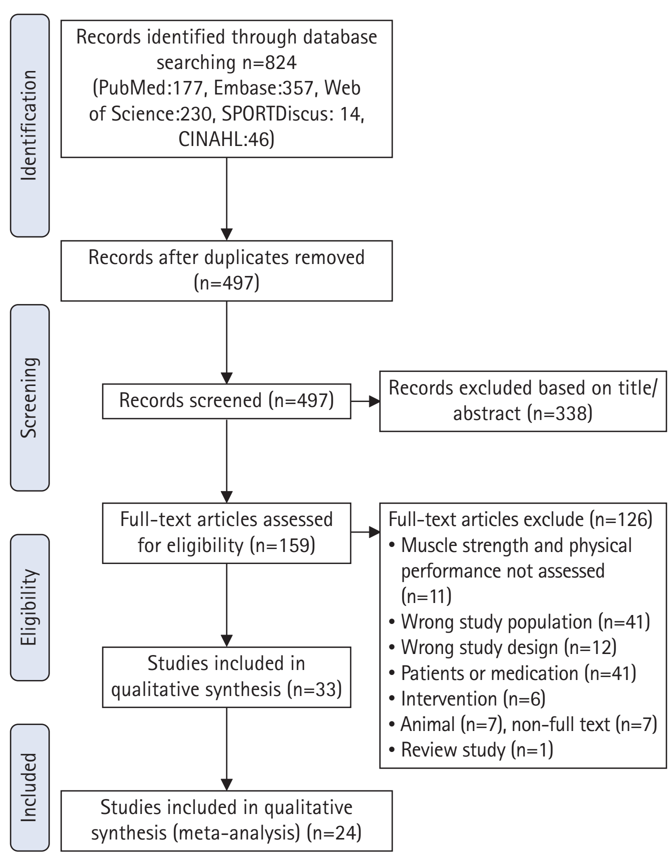

Fig. 1. Flow chart selection process.

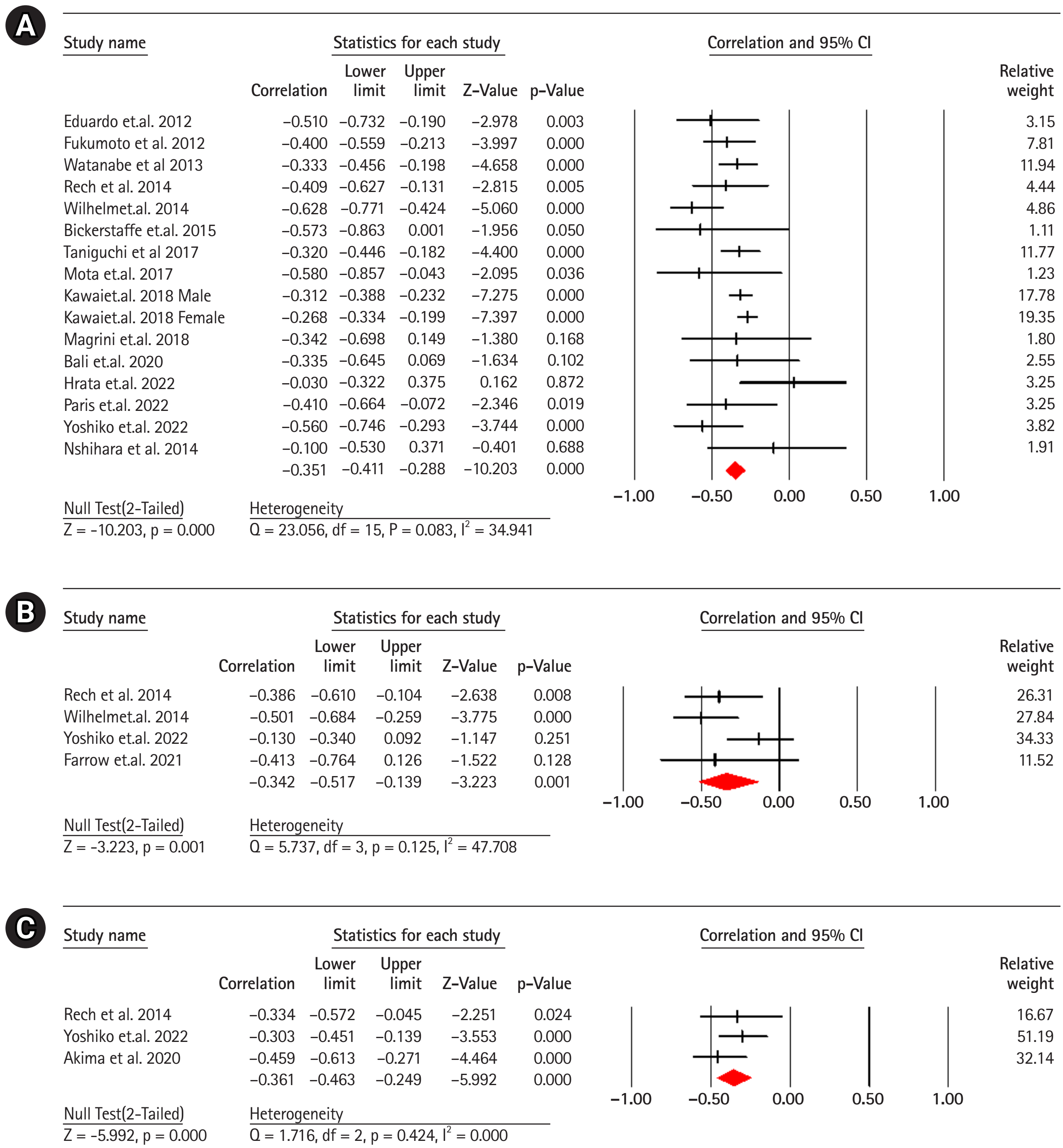

Fig. 2. Associations (Rz values) between echo intensity and (A) maximal strength, (B) explosive power, (C) handgrip strength. CI, confidence interval; df, degrees of freedom.

-0.07; $p = 0.94$; $I^2 = 66.50$), indicating no linear correlation between the two with moderate heterogeneity. Subgroup analysis showed a weak negative correlation between UGS and EI ($r = -0.22$; 95% CI, -0.32 to -0.11; $p < 0.001$; $I^2 = 0.00$), while there was a weak positive correlation between MGS and EI ($r = 0.22$; 95% CI, 0.11 to 0.32; $p < 0.001$; $I^2 = 0.00$) (Fig. 3).

Chair stand test

Thirteen studies (620 participants) investigated the association between EI and the chair stand test.[11-14,21,29,32,35-37] The combined effect size of EI and 30SS was $r = 0.07$ (95% CI, -0.04 to 0.18; $p = 0.22$; $I^2 = 86.64$), with a weak statistical correlation and considerable heterogeneity. Subgroup analyses showed a moderate negative correlation between EI and the 30SS test (r = -0.44; 95% CI, -0.59 to -0.26; $p < 0.001$; $I^2 = 45.41$) and between EI and the 5STS test (r = 0.32; 95% CI, 0.17 to 0.46; $p < 0.001$; $I^2 = 35.42$), respectively. We observed a weak positive correlation between EI and the TUG test (r = 0.29; 95% CI, 0.04 to 0.21; p = 0.02; $I^2 = 25.42$) (Fig. 3).

Publication Bias

The relative symmetry displayed in Fig. 3A indicates no apparent publication bias. Visual inspection of the funnel plot in Fig. 3B suggested insufficient evidence of publication bias, with an intercept result of 1.03 (SE = 2.10; 95% CI, -3.51 to 5.58; t = 0.48; df = 13; p = 0.63), indicating no strong evidence of publication bias (Supplementary Fig. S1).

DISCUSSION

This meta-analysis examined the correlation between EI in the

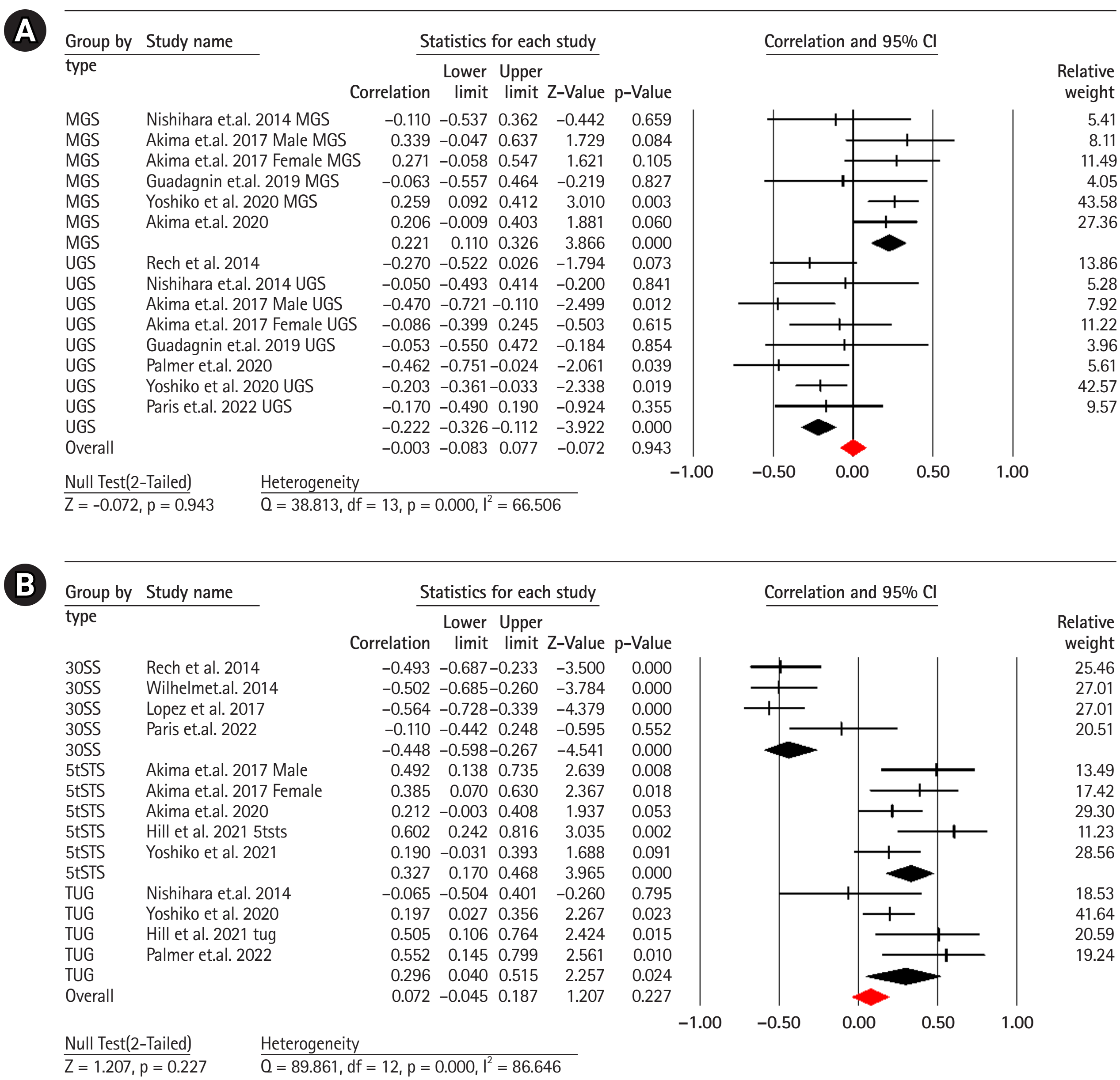

Fig. 3. Associations (Rz values) between echo intensity and (A) gait speed, (B) chair stand test. CI, confidence interval; df, degrees of freedom; MGS, maximal gait speed; UGS, usual gait speed; 30SS, 30-second sit-to-stand test; 5STS, 5-time sit-to-stand test; TUG, Timed Up-and-Go test.

thigh muscles, muscle strength, and physical functional performance in healthy older individuals.

Our results revealed a significant moderate inverse correlation between EI and maximal strength in the lower extremities, explosive power, and handgrip strength in this population. However, the meta-analysis showed contradictory evidence for the association between EI and physical functional performance, which appeared to be task-specific. In summary, the strength of the association between thigh EI and physical function may depend on the specific type of physical function test used.

Correlation between Muscle Strength and EI

The results of our meta-analysis suggested a moderately negative correlation between EI and muscle strength in older adults. Muscle quality, which is related to the amounts of muscle fiber and fat tissue, is an independent determinant of muscle strength. Gray-scale analysis of EI is a valuable tool for assessing muscle strength.[5] Furthermore, the relationships between EI and different types of strength exhibit unique features. EI and maximum strength are negatively correlated (r = -0.3), with the fat and connective tissue in muscles playing a significant role in isometric and isokinetic strength in older adults. This finding is consistent with those of previous studies showing a correlation between the EI of the rectus femoris muscle and isometric/isokinetic peak torque, with r values ranging from -0.40 to -0.67.[8,30] However, contrary to our study, these previous studies observed no relationship between thigh EI and maximal isometric strength.[38] One explanation for this discrepancy could be the use of different measurement techniques to assess EI. In EI determined from transverse images, the ultrasound probe positioning significantly affects the results.[5] Therefore, discrepant findings in the literature may be due to differences in probe orientation. The current evidence suggests that the accumulation of non-contractile components in thigh muscles significantly affects maximal knee extension and flexion strength in older adults.[28]

A previous study showed that older adults experience a more significant decline in explosive speed than in maximum muscle velocity.[39] Our results demonstrated a moderate correlation (r = -0.3) between EI and knee explosive power, which can be attributed to the increased intramuscular fat infiltration associated with aging. This change leads to a decrease in single-fiber contraction velocity and power output, alters mechanical muscle properties, increases muscle stiffness, and alters fiber shortening and bulging.[8,40] Additional neuromuscular variables contribute to the age-related decrease in explosive speed; specifically, the fast performance of older adults may be influenced by motor unit firing rate.[41] In addition, the decline in muscle strength associated with aging may be owing to factors beyond muscle mass, such as decreased proportion of fast type II fibers and reduced muscle excitatory neural activation.[42-44] Moreover, coactivation, which refers to opposing muscle mechanical action, is higher in older adults, resulting in reduced force production.[45]

The assessment of grip strength using a HGS is a practical approach for evaluating muscle strength in clinical contexts.[46] In addition to its ease of application, grip strength can serve as a crucial indicator of physical functionality and is associated with mortality rates in certain pathological conditions. Our meta-analysis identified a moderate correlation (r = -0.3) between EI strength and handgrip strength, consistent with the outcomes of various previous studies.[11,32,33]

Correlation between Physical Function and EI

Although we did not observe a significant association between EI and gait speed, subgroup analyses revealed a weak association between maximal and usual gait speeds. Previous research on older adults showed no significant correlation between the muscle EI of the quadriceps femoris and the 6-minute walk, which was attributed to an increase in subcutaneous fat thickness. However, the relationship became statistically significant after adjusting for subcutaneous fat.[34] These findings raise concerns about whether it is necessary to adjust for subcutaneous fat thickness in EI measurements for older adults.

We examined the relationship between chair-stand performance and EI. We observed a weak correlation between chair-stand performance and EI, with substantial heterogeneity. Previous studies comparing various types of chair tests have reported that a 30-second chair stand is the optimal parameter for predicting EI in older adults.[36] Subgroup analysis revealed a moderate correlation (r = 0.4) between 30-second chair stand performance and EI, supporting the previous finding that an increased proportion of non-contractile elements may lead to functional status deterioration with aging.[4] The high heterogeneity in the meta-analysis may have resulted from using different cutoff points. Age is a primary factor affecting chair-stand performance and EI and may confound the assessment of this association. Moreover, ankle plantar flexors exhibit a similarly strong association (r = 0.45–0.59) with chair function tests in older adults,[37] implying that muscle type may account for the lack of significant association between chair-stand tests and EI in our study.

In addition, EI obtained using ultrasound may be influenced by methodological factors such as subcutaneous fat correction, biological factors such as sex and race, and environmental factors such as daily physical activity and exercise,[5,47,48] which cannot be completely controlled in clinical settings. The inconsistency between the results of our meta-analysis and those of previous studies emphasizes the need to carefully consider confounding factors when examining the relationship between EI and physical function.

This study had several limitations. First, due to the lack of a standardized EI measurement method, we used raw EI data. Subcutaneous fat thickness may attenuate ultrasound findings and affect the reliability of muscle EI results. Second, insufficient data were available to perform a meta-analysis of muscles outside the thigh; therefore, the analysis does not represent the strength and overall function of the lower limb muscles. In addition, not all the studies controlled for confounding variables. Although this report examined the results in older adults, the included studies did not separately investigate participants by sex; therefore, potential differences between the sexes are unknown. Finally, the current meta-analysis was based on cross-sectional data; thus, the association does not imply causality. Therefore, the relationship between muscle structural characteristics, muscle strength, and physical function variables could not be determined.

Overall, our meta-analysis results support EI as an effective indicator for evaluating muscle strength and physical functional performance; however, the influence of factors such as different muscle types, age, and sex must be considered. Future research should explore the impact of these factors on this relationship to better understand the application of echogenicity in evaluating muscle strength and functional performance.

Conclusion

Our findings suggest that increased EI in the thigh muscles is associated with decreased strength and power in older individuals. However, we did not observe a significant association between EI and gait speed or mobility. Further well-designed studies with larger sample sizes and longer-term follow-ups are required to validate the practical implications of these results in predicting frailty and assessing risks in this population.

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The researchers claim no conflicts of interest.

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None.

AUTHOR CONTRIBUTIONS

Conceptualization, MK; Supervision, MK; Data collection, HY; Writing-original draft, HY, MK; Writing-review & editing, HY, MK.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4235/agmr.23.0101.

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Association between Toe Pressure Strength in the Standing Position and Maximum Walking Speed in Older Adults

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Background: Considering concerns about conventional toe grip strength, we devised a method to measure toe pressure strength in the standing position, which is close to the actual motion. This study examined the association between toe pressure strength in the standing position and walking speed among older adults. **Methods:** This cross-sectional study included 150 community-dwelling older adults (81±8 years, 73% female) who participated in the physical fitness test. We analyzed the correlation between the participants' maximum walking speed and physical function. Furthermore, we performed regression analysis with the maximum walking speed as the dependent variable to examine the association with toe pressure strength in the standing position. We also examined the association between maximum walking speed and toe pressure strength in the standing position by introducing a covariate. **Results:** Correlation analysis revealed a significant positive correlation between maximum walking speed and toe pressure strength in the standing position, with a moderate effect size ($r=0.48$, $p<0.001$). Moreover, multiple regression analysis with covariates showed an association between maximum walking speed and toe pressure strength in the standing position (standardization factor=0.13, $p<0.026$). **Conclusion:** Toe pressure strength in the standing position was associated with maximum walking speed. This finding clarifies the significance of assessing toe pressure strength in the standing position and suggests that enhanced toe pressure strength in the standing position may increase maximum walking speed.

Key Words: Toe pressure strength, Toe muscle strength, Older adults, Walking speed

INTRODUCTION

Toes play a significant role in stabilizing motor performance, including standing and walking.[1)] Toe muscle strength is a function of the toes. Older adults with decreased toe muscle strength have a higher risk of falling.[2,3)] Additionally, toe muscle strength in community-dwelling older adults has been associated with gait parameters, including decreased walking speed, swing time during walking, and shortened stride length.[4)] Furthermore, enhancing toe muscle strength improves balance ability.[5)] Therefore, toe muscle strength is associated with several physical functions.

While toe muscle strength has been assessed based on toe grip strength in the sitting position,[1-5] walking, standing, and falling occur in the standing position. Moreover, toe muscle strength is enhanced by weight bearing in the upright position.[6] Furthermore, we believe that assessment in the standing position is not only closer to the actual movement but also more reflective of an individual's ability. Toe grip strength is typically evaluated by measuring the force of deep flexion of the toes. However, no toe-bending movements are observed during gait and balance. Previous studies have shown that the toes press against the floor surface during exercise.[7] Furthermore, patients may complain of pain during toe grip strength assessment. Among interventions to increase toe grip strength, towel gathers are reportedly not only ineffective but also increase pain.[8] To address these concerns, we devised a method to assess the toe pressure strength in the standing position. We previously reported the high reliability of measured toe pressure strength in the standing position and its criterion-related validity as a measure of muscle strength.[9] In a study on older adults requiring long-term care, toe pressure strength in the standing position effectively discriminated the risk of falling.[10] Therefore, measuring toe pressure strength in the standing position is an evaluation method that can be used in clinical practice.

Walking speed is a vital sign of physical function and an indicator of health status.[11,12] It may decrease with age in the presence of motor or cardiovascular disorders.[13,14] Maintaining walking speed is essential for older adults to perform activities of daily living without difficulty. For example, a certain walking speed is required to complete a pedestrian crossing in time. In addition, some situations require increased walking speed, including when others are waiting or when the time is short. We hypothesized that toe pressure in the standing position, which is close to the actual movement, may be a gait speed-related function. This is because kicking off while pressing down on the floor with the toes is necessary for walking. However, no reports have clarified the association between maximum walking speed and toe pressure strength in the standing position in older adults with disabilities.

Therefore, we examined the association between the maximum walking speed and toe pressure strength in the standing position. We believe that this study will assist in the creation of rehabilitation programs aimed at improving walking speed in older adults. Furthermore, we aimed to demonstrate the significance of assessing toe pressure in the standing position in older adults.

MATERIALS AND METHODS

Participants

This cross-sectional study included healthy residents aged ≥65 years who participated in physical fitness tests conducted at community centers and who were not hospitalized due to illness or certified as long-term care residents, as well as older adults certified as requiring long-term care undergoing physical fitness tests at day-care rehabilitation centers. Participant recruitment was performed by posting on a website, distributing flyers, and calling participants by staff members who conducted the physical fitness test. The exclusion criteria were individuals who needed assistance in walking, had deficiencies in the assessment items, and were aged ≤64 years.

The participants were fully informed of the study content and purpose and their cooperation was sought after gaining their understanding. Participation in this study was voluntary, and non-participation or withdrawal during the study was not detrimental. Additionally, before starting this study, we obtained permission from the director and site manager of the facility where the study was conducted. This study was approved by the Ethical Review Committee of Nishikyushu University (No. 210077). All participants provided informed consent. Also, this study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[15]

Measurements

We measured basic participant information including sex, age, height, weight, body mass index, and level of long-term care. The required level of care is certified by the Japanese government through the long-term care insurance certification system. In Japan, the long-term care insurance system was introduced in response to the accelerated aging of the population and accompanying increases in the level of long-term care.[16] This system consists of two levels, support and care, and is further classified into seven levels: support 1–2 and care 1–5.[17] We also obtained the main comorbidities of the participants from their medical records. We measured physical functions including toe pressure strength in the standing position, handgrip strength, knee extension strength, and maximum walking speed. Cognitive function was assessed using the Mini-Mental State Examination (MMSE).

Toe pressure strength in the standing position

We measured toe pressure strength in the standing position using a toe pressure measuring device (S-14030; Takei Scientific Instruments Co. Ltd., Niigata, Japan). The measurement was made by securing the participant's ankle joint with a belt, with the arms hanging loosely, and asking the participants to look straight ahead. The use of handrails or similar aids was not permitted during the measurements. To ensure accurate results, only the tips of the toes from the first to fourth metatarsophalangeal joints were placed on the force plate, and any strength of the ankle joint plantar flexion muscle was excluded from the measurement. The participants were instructed to keep their heels in place and apply force to the floor using only their toes. At the time of measurement, the subtalar joint of the foot was fixed in an intermediate position. Toe pressure was applied to the floor for 5 seconds, and the participants were permitted to adjust their weight while applying the force. As per the specifications of the device, the measured values only increase if a vertical force is applied to the force plate using the toes and not simply by shifting the center of gravity forward. Measurements were taken twice on each side. We recorded the toe pressure strength in the standing position as the sum of the maximum values on the left and right sides divided by the body weight (Fig. 1).

Other measurements

We measured handgrip strength using a Smedley-type digital grip strength meter (TKK 5401; Takei Scientific Instruments, Niigata, Japan). While standing, the participants were instructed to straighten their elbow joint and position the proximal interphalangeal joint of their index finger at a 90° angle. The evaluator ensured that the upper limbs did not contact the lower limbs or torso during the measurements. Measurements were taken twice, alternating left and right, and the sum of the left and right values was divided by body weight to obtain the handgrip strength.

We measured knee extension strength using a handheld dynamometer (μTasF-1; Anima Co. Ltd., Tokyo, Japan) with the participants sitting with their trunk upright and arms crossed over the chest. The sensor was attached to the lower leg near the ankle with a belt. Measurements were taken twice, alternating left and right, and the sum of the left and right values was divided by the body weight to obtain the knee extension strength.[18]

We measured the maximum walking speed using a digital stopwatch. We instructed the participants to walk 11 m on a flat surface at a brisk pace and recorded the time it took to cover the middle 5-m section. The test was performed twice, and the fastest walking speed was recorded.

MMSE was assessed face-to-face using a questionnaire. The MMSE is the most commonly used brief cognitive assessment tool, with demonstrated reliability and validity.[19] We used the MMSE in this study to ascertain how the participants understood the instructions given during the measurements.

Statistical Analysis

We initially performed Pearson correlation analysis for the measures hypothesized to correlate with maximum walking speed. The effect size (ES) was determined according to the r value—small ($ES \leq 0.1$), medium ($0.1 < ES \leq 0.3$), and large ($ES > 0.5$).

We performed a regression analysis with the maximum walking speed and toe pressure strength in the standing position as dependent and independent variables, respectively. Additionally, Model 2 was created, which included knee extension strength, sex, age, height, and level of long-term care required as covariates. We con-

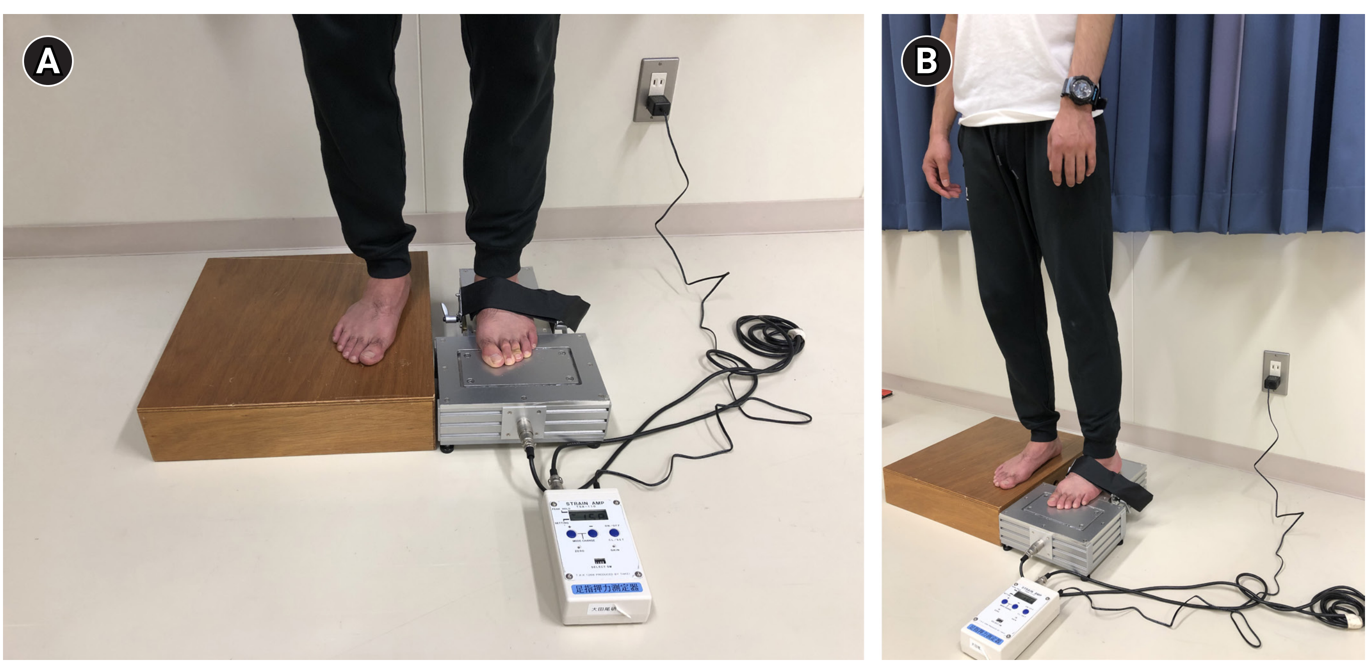

Fig. 1. (A, B) How to measure the toe pressure strength in the standing position. The force plate is adjusted so that only the toes are placed on the force plate and is secured with a belt so that it does not reflect ankle plantar flexion muscle strength.

firmed the validity of the regression equation using analysis of variance (ANOVA) and determined the goodness-of-fit of the multiple regression equation using the R^2 value. We determined the multicollinearity of the multiple regression equation based on the variance inflation factor (VIF).

We used a two-tailed test to calculate the sample size for the correlation analysis using the following parameters ES (r) = 0.3, α error = 0.05, and power = 0.8, which indicated that 82 participants were required. The number of samples required for multiple regression analysis was calculated as follows: ES (f^2) = 0.15, α error = 0.05, and power = 0.8, thereby requiring six independent variables. Therefore, this study included a total of 98 participants. The statistical significance level was set at 5%, and we used IBM SPSS Statistics for Windows, version 28.0 (IBM Corp, Armonk, NY, USA) for the analyses. G*Power 3.1.9.7 was used for sample size calculation.

RESULTS

Participant Selection Criteria

The participant selection process is detailed in Fig. 2. This study included 239 participants who completed the physical fitness test. We excluded 3, 53, and 33 participants who needed assistance with walking, had missing assessment items, and were < 64 years of age, respectively. After excluding these 89 participants who met the exclusion criteria, the analysis included 150 community-dwelling older adults (81 ± 8 years, 73% female) who participated in the physical fitness test (Fig. 2). The participants' characteristics are shown in Table 1.

Correlation Analysis of Each Measured Item

Table 2 presents the results of the correlation analyses. These results showed a significant positive correlation between the maximum walking speed and toe pressure strength in the standing position, indicating moderate ES ($r = 0.48$, $p < 0.001$). Furthermore, maximum walking speed was significantly positively correlated with handgrip strength ($r = 0.57$, $p < 0.001$), knee extension strength ($r = 0.67$, $p < 0.001$), and height ($r = 0.23$, $p = 0.005$) and negatively correlated with age ($r = -0.52$, $p < 0.001$). Moreover, toe pressure strength in the standing position was positively correlated with handgrip strength ($r = 0.55$, $p < 0.001$), knee extension strength ($r = 0.61$, $p < 0.001$), and age ($r = 0.20$, $p = 0.020$).

Association between Maximum Walking Speed and Toe Pressure Strength in the Standing Position

Table 3 also presents the results of the regression analyses. First, we

Table 1. Characteristics of participants (n=150)

Characteristic	Value
Sex, female	109 (73)
Age (y)	81 ± 8
Height (cm)	152.1 ± 9
Weight (kg)	52.7 ± 9.7
BMI (kg/m²)	22.7 ± 3.3
Long-term care levels	
Care 1	38 (25)
Care 2	42 (28)
Support 1	20 (13)
Support 2	3 (2)
Support 3	1 (1)
Support 5	1 (1)
Comorbidity	
No comorbidities	36 (24)
Cerebrovascular diseases	30 (20)
Orthopedic disease	61 (41)
Respiratory and circulatory disease	12 (8)
Other comorbidities	11 (7)
Toe pressure strength in the standing position (kgf/kg)	0.63 ± 0.29
Handgrip strength (kgf/kg)	0.77 ± 0.24
Knee extension strength (kgf/kg)	0.59 ± 0.28
Max gait speed (m/s)	1.3 ± 0.6
MMSE	26 ± 3

Values are presented as number (%) or mean±standard deviation.
BMI, body mass index; MMSE, Mini-Mental State Examination.

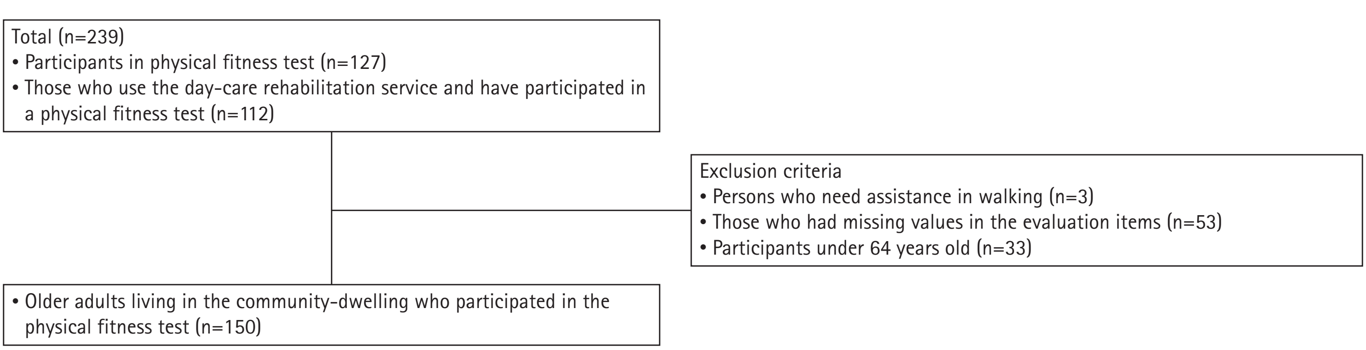

Fig. 2. Selection of analytes.

Table 2. Correlation analysis with maximum walking speed

	Max gait speed	Toe pressure strength in the standing position	Handgrip strength	Knee extension strength	Age
Toe pressure strength in the standing position	0.48**	-	-	-	-
Handgrip strength	0.57**	0.55**	-	-	-
Knee extension strength	0.67**	0.61**	0.62**	-	-
Age	-0.52**	-0.20*	-0.30**	-0.36**	-
Height	0.23**	0.12	0.32**	0.16	-0.41**

Pearson correlation analysis was performed.
*p<0.05, **p<0.01.

performed a single regression analysis with the maximum walking speed and toe pressure strength in the standing position as the dependent and independent variables, respectively. The results revealed a significant association of maximum walking speed with toe pressure strength in the standing position (standardization factor = 0.48, $p < 0.001$). The results of the multiple regression analysis with knee extension strength, sex, age, height, and level of long-term care as covariates demonstrated the association of maximum walking speed with toe pressure strength in the standing position in Model 2 (standardization factor = 0.13, $p < 0.026$). The results of the ANOVA for Model 2 were significant ($p < 0.001$), with an R^2 value of 0.74. No variables with VIF > 5 were identified.

DISCUSSION

In this study, we examined the association between toe pressure strength in the standing position, which is similar to the actual movement, and maximum walking speed in older adults, including those who were certified as requiring long-term care. Furthermore, we examined the association between maximum walking speed and toe pressure strength in the standing position, even after introducing variables potentially associated with maximum walking speed in older adults.

First, we examined the correlation between the maximum walking speed and each of the measures through Pearson correlation analysis. We observed a significant correlation between maximum walking speed and toe pressure strength in the standing position. We also observed a moderate effect. In other words, the stronger the toe pressure strength in the standing position, the faster the maximum walking speed. This result was consistent with our hypothesis. A previous study on young participants showed a correlation between the toe muscle strength measured by toe grip strength and walking speed.[20] We observed results similar to those shown in previous studies for toe pressure strength in the standing position, which is close to the actual movement. To increase walking efficiency, the foot should be stiffer and exert a more effective force to push against the ground.[21] One mechanism that increases foot stiffness is the windlass mechanism, wherein the medial longitudinal arch is elevated by toe extension, thereby improving the energy efficiency between the foot and the ground.[22] Therefore, to increase walking efficiency, the toes should be pressed against the ground without flexion. This supports the possibility that the toe pressure strength in the standing position is more important than toe grip strength, which is measured by toe flexion.

The results of the regression analysis showed that toe pressure strength in the standing position was significantly associated with the maximum walking speed as the dependent variable. Multiple regression analysis in Model 2, which was adjusted for covariates, also showed a significant association between maximum walking speed and toe pressure strength in the standing position. Interestingly, toe pressure strength in the standing position was associated with gait speed in older adults even when factors already associated with gait speed were introduced. This finding indicated that toe pressure strength in the standing position contributes to maximum walking speed in older adults. Toe muscle strength may contribute to the motion that accelerates the center of gravity in the terminal stance during walking.[23] In this stance, approximately 20%–30% of the body weight is applied to the toes[24] and the toes perform the important movement of kicking while supporting the body weight. Therefore, because the body weight must be supported with the toes while kicking off the floor to generate propulsive force during walking, we speculate an association between maximum walking speed and toe pressure strength in the standing position. Previous studies on maximum walking speed identified toe muscle strength as a factor affecting propulsive force during walking.[25] Therefore, we defined maximum walking speed as the dependent variable in this study. Interestingly, older adults have reported increased pressure on all toes when conditioned to walk at maximum speed.[26] These results support the significance of evaluating toe pressure strength in the standing position, which is closer to the actual movement than toe grip strength in the sitting position. In addition, during walking, the center of pressure (COP) shifts from the heel toward the big toe. We previously showed that toe pressure strength in the standing position may contribute more

Table 3. Association between maximum walking speed and toe pressure strength in the standing position

		Non-standardization factor	Standardization factor	p-value	95% CI		VIF
					Lower	Upper	
Model 1	Toe pressure strength in the standing position	0.94	0.48	< 0.001	0.65	1.23	
Model 2	Toe pressure strength in the standing position	0.24	0.12	0.028	0.03	0.44	1.66
	Knee extension strength	0.01	0.28	< 0.001	0.01	0.02	2.16
	Sex (male 0, female 1)	0.38	0.30	< 0.001	0.21	0.56	2.77
	Age	-0.01	-0.07	0.224	-0.01	0.00	1.73
	Height	0.02	0.23	0.001	0.01	0.02	2.89
	Long-term care levels (reference: Non-long term care certification)						
	Care 1	-0.51	-0.36	< 0.001	-0.69	-0.33	2.32
	Care 2	-0.65	-0.50	< 0.001	-0.81	-0.49	2.29
	Support 1	-0.61	-0.36	< 0.001	-0.82	-0.40	2.21
	Support 2	-0.60	-0.15	0.001	-0.96	-0.24	1.21
	Support 3	-1.17	-0.17	< 0.001	-1.74	-0.60	1.04
	Support 5	-1.49	-0.22	< 0.001	-2.07	-0.91	1.07

Model 1: Single regression analysis, ANOVA <0.001, R^2=0.23, Durbin-Watson ratio=1.049.
Model 2: Multiple regression analysis, ANOVA <0.001, R^2=0.77, Durbin-Watson ratio=1.677.
CI, confidence interval; VIF, variance inflation factor.

to the forward shift of the COP than toe grip strength.[27] Our previous findings support the present findings that gait with the forward movement of the COP is associated with toe pressure strength in the standing position, as well as our speculation that toe pressure strength in the standing position is more strongly associated with gait speed in older adults than toe grip strength.

A strength of this study is its novel determination of the association between toe pressure strength in the standing position and maximum walking speed in older adults. The results of our study of older adults, including those certified as requiring long-term care, demonstrated the need to measure toe pressure in the standing position, in addition to other physical functions, in assessing the reduction of maximum walking speed.

This study has several limitations. First, we did not measure toe grip strength; therefore, we could not compare this value with toe pressure strength in the standing position. However, a previous study examining the association between toe grip strength and maximum walking speed reported a correlation coefficient (r) of 0.42.[28] Determining which is more correlated is impossible; however, a comparison of the correlation coefficients suggested similar or better correlations. Additional studies are needed to determine which toe evaluation is more relevant to the maximum walking speed by performing simultaneous measurements. Furthermore, additional studies are also needed to perform more accurate measurements of muscle strength through further validation of methods that consider toe and foot morphology. Second, while we examined the association between the maximum walking speed and toe pressure strength in the standing position, we did not measure gait parameters in detail. Previous reports indicate that older adults increase their cadence but not their stride length when increasing their walking speed.[29] Therefore, detailed gait parameters should be considered in future studies. Third, we considered a small number of variables. Therefore, additional studies are needed to comprehensively incorporate and analyze the variables potentially related to walking speed. Finally, the cross-sectional study design prevented the identification of causal relationships. Therefore, future longitudinal studies are needed. However, considering concerns regarding toe grip strength in the sitting position, we clarified the significance of measuring toe pressure strength in the standing position, which is closer to the actual movement. We believe that our study results will contribute to future rehabilitation of older adults.

In conclusion, the results of this study demonstrated the positive correlation between toe pressure strength in the standing position and maximum walking speed in older adults. Moreover, toe pressure strength in the standing position was associated with maximum walking speed. Our results suggest that assessing toe pressure strength in the standing position may be used to help older adults maintain and improve their maximum walking speed, which plays a significant role in activities of daily living. Furthermore, we demonstrated the significance of evaluating toe pressure strength in the standing position.

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CONFLICT OF INTEREST

The researchers claim no conflicts of interest.

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None.

AUTHOR CONTRIBUTIONS
Conceptualization, TK, HO, TT; Data curation, TK, HO, MH, ST, TT; Formal analysis, TK, SS, MM; Investigation, TK, HO, MH, ST, TT; Methodology, TK, MH; Project administration, SS, MM; Supervision, HO, TT; Validation, KO, GH, YA, YH; Writing-original draft, TK; Writing-review & editing, KO, GH, YA, YH.

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Psychosocial Determinants of Knee Osteoarthritis Progression: Results from the Promoting Independence in Our Seniors with Arthritis Study

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Background: Knee osteoarthritis (OA) is a common cause of physical disability among older adults. While established risk factors for knee OA include age and increased body weight, few studies have examined psychosocial risk factors or progression of knee OA. **Methods:** The Promoting Independence in our Seniors with Arthritis study recruited participants aged 65 years and over from orthopedic outpatients and community engagement events. Participants were invited to annual visits during which knee OA symptoms were assessed with the Knee Injury and Osteoarthritis Outcome Score (KOOS), social network using the 6-item Lubben Social Network Scale and anxiety and depression using the Hospital Anxiety and Depression scale. Knee OA worsening was defined by a 5% reduction in mean KOOS scores at the last visit compared to the first visit. **Results:** Data were available from 148 participants, mean age 66.2±6.5 years and 74.1% female, of whom 28 (18.9%) experienced OA worsening over a median follow-up period of 29 months. Univariate analyses revealed that age, sex, height, grip strength, and social network were associated with OA worsening. Social network remained statistically significantly associated with OA worsening after adjustment for age and sex difference (odds ratio=0.924; 95% confidence interval, 0.857–0.997). The relationship between social network and OA worsening were attenuated by both depression and handgrip strength at baseline. **Conclusion:** Psychological status and muscle strength may be modifiable risk factors for social network which may in turn prevent knee OA worsening and should be targeted in future intervention studies.

Key Words: Geriatrics, Anxiety, Knee osteoarthritis, Disease progression, Depression, Social networking

INTRODUCTION

The pathophysiology of osteoarthritis (OA) has evolved from a disease of cartilage destruction to a systemic disease that affects the entire joint via mechanical, inflammatory, and metabolic factors, leading to a common final pathway of joint destruction.[1] The prevalence of knee OA increased from 164 million cases to 364 million between 1990 and 2020, making OA a leading cause of morbidity among older adults, subsequently imposing a great cost to society as whole.[2]

Psychological distress is common among older adults with depression, affecting an estimated 13% of the older population,[3] whereas anxiety affects up to 10.2%.[4] This is especially relevant in the post-coronavirus disease 2019 environment, in which 20.9% of the older cohort reportedly suffers from anxiety.[5] Patients with arthritis have increased odds ratios of developing psychological sequelae.[6] Furthermore, physical therapy prevents depressive symptoms in older adults with knee OA and subsyndromal depressive symptoms.[7]

However, few studies have addressed the psychological and social determinants of knee OA and the factors that determine the worsening of knee OA symptoms. Our study attempted to address these gaps by evaluating the psychosocial factors associated with the worsening of OA in a prospective cohort followed up over a 4-year period.

MATERIALS AND METHODS

Data were utilized from the Promoting Independence in Seniors with Arthritis (PISA) longitudinal study comprising community-dwelling adults aged >65 years with and without knee pain recruited from the orthopedic clinic of the Universiti Malaya Medical Centre (UMMC) and a local hospital catchment area through public engagement events and word-of-mouth advertising. All participants provided written informed consent on recruitment before their first assessment. Individuals who did not provide informed consent were excluded. The UMMC Medical Research Ethics Committee provided ethical approval for this study (MECID No. 20147-390). This study complied the ethical guidelines for authorship and publishing in the *Annals of Geriatric Medicine and Research*.[8]

Data Collection

Data were collected and managed using the REDCap electronic data capture tool hosted at the Universiti Malaya.[9,10] During the first visit, the patients' basic demographic data, including age, sex, marital status, and medical history, were recorded. Other parameters and new medical conditions were recorded during every annual visit, including physical and physiological measurements of height, weight, lying and standing blood pressure, muscle strength, and gait and balance. Additionally, psychosocial assessments, including the evaluation of anxiety, depression, life satisfaction, social networks, and social participation, were obtained. Knee OA symptom severity was measured using the Knee Injury and Osteoarthritis Outcome Score (KOOS).

Physical Performance

Muscle strength was determined using handgrip strength measured with a Jamar grip strength dynamometer (Sammons Preston, Bolingbrook, IL, USA). Handgrip strength was first measured in the dominant hand and then in the non-dominant hand. Each patient was asked to sit on a chair with the forearm resting comfortably on the armrest of the chair. The arm was flexed at 90° at the elbow and each patient was asked to squeeze the dynamometer as hard as possible when ready. The readings were recorded three times, and the average of the readings was calculated. This process was repeated for the non-dominant hand.

In the Timed-Up-and-Go test, each patient was asked to sit on a chair. Before starting the test, a marker was placed three meters from the chair. Each patient was then asked to stand up, walk in a straight line toward the mark, make a U-turn, walk back to the chair, and sit down as quickly as possible. The time required to complete this task was recorded using a stopwatch. The participants were asked to walk at their normal pace and speed with shoes on and use regular walking aids if required. A completion time of >13.5 seconds indicates impaired lower limb function.[11]

Functional reach was measured with each participant standing close to the wall but not touching it. A tape measure was fixed to the wall at the level of the shoulder of the outstretched arm, parallel to the floor. The distance was measured from the fingertip of the middle finger. The participants were then asked to reach forward as far as they could without losing balance or taking steps forward. The functional reach was calculated as the difference between the final and initial measurements and was measured in centimeters.

Life Satisfaction

The Life Satisfaction Checklist was first designed by Fugl-Meyer in 1985 to assess post-stroke patients. It consists of seven items rated on a 6-point Likert scale.[12] Individual satisfaction with life was assessed using an extended 9-item version of the Life Satisfaction Questionnaire (LiSAT-9). The answers were scored on a Likert scale of 1 to 6, indicating "very dissatisfying," "dissatisfying," "rather dissatisfying," "rather satisfying," "satisfying," and "very satisfying," respectively. The components included the participants' perception of life, vocational situation, finance, leisure, social contact, sexual life, self-care ability, family life, and partner relationships. A higher score denotes greater satisfaction.

Activities of Daily Living

The Lawton Instrumental Activity of Daily Living (IADL) was first published in 1969.[13] Lawton eight components to assess IADL were assessed at every visit in the present study. These eight were using a telephone, shopping, preparing food, housekeeping, doing laundry, using transportation, taking medications, and handling finances. Those who could not handle the task were assigned a score of zero, with higher scores indicating better functional capacity. Katz's index of independence in activity of daily living (ADL) was first proposed in 1963. It consists of six questions regarding bathing, dressing, toileting, transferring, maintaining continence, and feeding. A higher score indicates a higher level of independence.[14)]

Social Participation and Network

Social participation was assessed using Keele Assessment of Participation (KAP), comprising seven questions assessing the respondent's ability to move around in the house, move outside the house, perform self-care, look after the home, look after belongings, meet and speak to other people, and manage finances. Four additional questions were only triggered by positive responses to having dependents, participating in paid or voluntary work, or courses for training or education. The scores assigned were zero for all of the time, one for most of the time, two for some of the time, three for sometimes, and four for never. Lower scores indicate better participation, and total scores range from 0–36. The KAP was first published in 2005.[15)]

The Lubben Social Network Scale is a six-item self-reported questionnaire that measures social engagement with friends and family.[16)] The scale consists of three questions related to relationships with family and three questions related to friends. Responses are scored from zero for none to five points for nine or more people, wherein a higher scores indicates a better social network.

Measurement of Anxiety and Depression

Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale. The responses were scored according to the frequency the individual experienced each symptom, with three points assigned for "Yes, definitely," two for "Yes, sometimes," one for "No, not much," and zero for "No, not at all." Higher scores indicate greater levels of anxiety and depression. The assessed components include sleep quality, a feeling of fright or panic, misery and sadness, anxiety at leaving the house, apathy, palpitations or "butterflies" in the stomach, appetite, scared feelings, feeling life is not worth living, anhedonia, restlessness, irritability, slowing down, and worry. All odd-numbered questions pertain to depression, whereas even-numbered questions pertain to anxiety.[17,18)]

Knee Osteoarthritis Injury and Outcome Score

At each review, the KOOS questionnaire was administered. The KOOS was chosen as the outcome variable because it is a freely available validated measure,[19)] comparable to the Western Ontario and McMaster Universities Arthritis Index (WOMAC).[20)] The KOOS consists of five subscales: symptoms, pain, ADL, function, sports and recreational activities, and quality of life. Responses were first assigned values from zero to four, indicating "never" to "always," respectively. Domain scores were obtained by summing the scores of individual items. The percentage score was calculated by dividing the sum score by the maximum possible total score and multiplying it by 100%. The mean KOOS score was then calculated as the sum of the percentage scores for each domain divided by the number of domains. A higher percentage score indicated a lower severity of knee OA. The KOOS-symptoms section contained seven questions, the KOOS-pain section contained nine questions, the KOOS-ADL section had 17 questions, the KOOS-sports section had five questions, and the KOOS-quality of life section had four questions. The KOOS was published in 1998, based on the WOMAC, and is self-administered.[19)]

Participants were included if they completed the KOOS during at least two visits. For all participants, the KOOS scores from the first and last visit were considered the baseline and follow-up scores, respectively. The presence of worsening OA was determined using an arbitrary cutoff of 5%, considering slight fluctuations in scores between visits.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY, USA). Summary statistics are presented in comparison tables containing the means and standard deviations for continuous variables and frequencies and percentages for categorical variables. We performed statistical comparisons using the Student independent t-test for continuous data and the chi-square test for categorical data. Considering the limited number of patients who experienced worsening knee OA, adjustments were made only for social networks in both anxiety and depression, using logistic regression analysis to determine potential mediating effects.

RESULTS

The PISA study recruited a total of 230 patients between 2015 and 2019. The maximum, mean, and median follow-up periods were 48 months, 29.23 months, and 21 months, respectively. Among the 230 participants, 157 completed two visits, 119 completed three visits, and 100 participants attended all four assessments. Of the 148 participants who underwent at least two KOOS measurements, 28 (18.9%) demonstrated knee OA worsening. The basic characteristics of the participants according to worsening symptoms, are summarized in Table 1. Patients with worsening knee OA had significantly lower standing height, right handgrip strength, and Lubben Social Network Scale scores than those without worsening OA. No other basic characteristics differed significantly between patients who demonstrated worsening knee OA symptoms as measured by the KOOS.

We evaluated the factors that predicted the worsening of knee

Table 1. Basic characteristics according to the presence and absence of worsening of knee osteoarthritis

Characteristic	No worsening (n = 120)	Knee OA worsening (n = 28)	p-value
Age (y)	65.9 ± 6.2	67.9 ± 7.6	0.148
Sex, female	81 (68.6)	22 (78.6)	0.362
Height (m)	159.5 ± 7.6	155.6 ± 8.4	0.022*
Weight (kg)	61.4 ± 11.2	60.6 ± 16.0	0.751
Right handgrip strength (kg)	24.3 ± 9.3	20.4 ± 5.4	0.034*
Left handgrip strength (kg)	22.6 ± 8.7	19.7 ± 5.6	0.107
Mean left and right handgrip strength (kg)	23.6 ± 8.7	19.7 ± 5.6	0.057
Timed-up-and-go (s)	11.2 ± 4.5	12.8 ± 4.8	0.100
Functional reach (cm)	28.1 ± 9.3	26.1 ± 6.8	0.285
Anxiety score	4.3 ± 4.2	5.1 ± 5.1	0.357
Depression score	4.8 ± 3.8	6.3 ± 4.0	0.072
Life satisfaction	4.9 ± 3.8	4.8 ± 1.0	0.903
Basic activities of daily living	5.8 ± 0.6	5.8 ± 0.4	0.866
Instrumental Activities of daily living	7.6 ± 1.0	7.4 ± 1.2	0.408
Social participation	3.1 ± 3.7	3.9 ± 3.9	0.318
Social network	17.5 ± 5.6	15.0 ± 5.8	0.042*
Total KOOS	81.5 ± 18.1	77.8 ± 16.6	0.355
Myocardial infarction	2 (1.7)	2 (7.4)	0.160
High cholesterol	60 (51.3)	11 (40.7)	0.395
High blood pressure	46 (39.3)	12 (44.4)	0.667
Stroke	8 (6.8)	0 (0)	0.352
Diabetes mellitus	18 (15.4)	3 (11.1)	0.765

Values are presented as mean±standard deviation or number (%).
OA, osteoarthritis; KOOS, Knee Injury and Osteoarthritis Outcome Score.
*p<0.05.

OA using binary logistic regression. Table 2 shows the unadjusted odds ratios for age, sex, height, right handgrip strength, depression, and social network scale. We defined statistically significant factors as those with 95% confidence intervals that did not exceed unity. Univariate analysis revealed a significant association between worsening knee OA and social networking. While the association between depression and worsening knee OA was not statistically significant, when depression was included in the multivariate analysis, the association between social networks and the worsening of knee OA was attenuated. This indicated that depression mediated the effects of social networks on the worsening of knee OA (Table 2). A similar analysis repeated for anxiety (Table 3) showed that the effects of social networks on the worsening of knee OA were mediated by anxiety.

DISCUSSION

Our findings suggest that worsening knee OA is associated with a reduced social network at baseline. However, the relationship between worsening knee OA and social networks was accounted for by depression and anxiety at baseline. A temporal relationship may exist between social networks and knee OA progression, as the worsening of knee OA is a longitudinal measure.

The progression of knee OA has traditionally been assessed radiographically using the Kellgren–Lawrence classification. However, these changes did not correlate with symptoms, indicating that structural changes, rather than radio-opacity, do not necessarily correspond to symptoms.[21] Magnetic resonance imaging (MRI) has been suggested as a preferable imaging modality for assessing the severity of knee OA; however, this method is resource-intensive and limited in terms of accessibility, and disagreement remains regarding the clinical significance of certain MRI findings.[22] Hence, we used a functional measure, the KOOS, to determine the progression of knee OA in our study.

The relationship between lower standing height and an increased risk of worsening OA has not been previously reported. However, genome-wide sequencing has identified multiple loci associated with knee OA[23]; some of the identified loci are associated with height, although the direction of the association remains unclear.[24] The relationship between height and knee OA is confounded by differences in age and sex and probably by female predominance and occupational association with knee OA.[25]

Worsening knee OA symptoms were significantly associated with weaker right handgrip strength. Handgrip strength has not previously been evaluated in the limited studies addressing the progression of OA despite findings that physical therapy is benefi-

Table 2. Binary logistic regression for factors associated with knee osteoarthritis worsening

	Odds ratio (95% CI)							
	Unadjusted	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Age–	1.047 (0.984–1.114)	1.059 (0.992–1.131)	1.031 (0.960–1.107)	1.034 (0.963–1.109)	1.044 (0.978–1.116)	1.053 (0.984–1.127)	1.033 (0.961–1.111)	1.004 (0.975–1.117)
Sex	1.675 (0.627–4.476)	1.980 (0.702–5.590)	0.680 (0.142–3.262)	0.850 (0.202–3.575)	1.599 (0.541–4.724)	2.332 (0.770–7.056)	1.126 (0.247–5.144)	2.002 (0,634–6.324)
Height	0.934 (0.879–0.991)	-	0.922 (0.843–1.008)	-	-	-	-	-
Right handgrip	0.940 (0.887–0.997)	-	-	0.937 (0.866–1.014)	-	-	0.946 (0.871–1.027)	-
Depression	1.096 (0.990–1.213)	-	-	-	1.080 (0.969–1.203)	-	-	1.050 (0.940–1.172)
Lubben	0.927 (0.861–0.999)	-	-	-	-	0.924 (0.857–0.997)	0.927 (0.858–1.001)	0.932 (0.863–1.007)

Model 1, age, sex; Model 2, age, sex, height; Model 3, age, sex, right handgrip; Model 4, age, sex, depression; Model 5, age, sex, Lubben; Model 6, age, sex, Lubben, right handgrip; Model 7, age, sex, Lubben, depression; CI, confidence interval.

Table 3. Binary logistic regression social network causing worsening of knee osteoarthritis symptoms adjusted for anxiety

	Odds ratio (95% CI)	
	Unadjusted	Model 1
Anxiety	1.044 (0.953–1.143)	1.020 (0.929–1.120)
Lubben	0.927 (0.861–0.999)	0.928 (0.860–1.000)

Model 1, anxiety, lubben; CI, confidence interval.

cial to patients with knee OA.[26] The OA presence may precede the development of muscle wasting or sarcopenia. However, factors predisposing patients to reduced handgrip strength, such as depression and noncommunicable disorders, may also predispose patients to worsening knee OA.

Previous studies have established the association between knee OA and social isolation.[27] The present study additionally identified an association between OA worsening and reduced social network, as measured using Lubben six-item Social Network Scale. The relationship between OA worsening and social networks was accounted for by differences in depression and anxiety, suggesting that the deterioration in knee OA symptoms is mediated by psychological issues. Low social support is associated with depression.[28] This association has also been observed in the Netherlands[29] and Malaysia.[30] Previous studies have also reported an association between lower social support and grip strength.[32] Social networking also mediates the effects of negative life events on the development of depression in older adults.[33] Yamashita et al.[34] found that the combination of social networks and financial incentives promoted physical activity more than financial incentives alone. Moreover, the positive association of smaller social networks with metabolic syndrome could be partially explained by physical inactivity.[35] Even online social networking shows this effect independent of physical meetings.[36]

Fonseca-Rodrigues et al.[37] reported a positive correlation between pain measured using the WOMAC, anxiety, and depression in their cross-sectional study. They also found that arthritis led to depressive symptoms.[6] However, the presence of depression at baseline was not associated with the progression of knee OA, suggesting that depression is a consequence of knee OA rather than a contributory factor to its progression. These findings highlight the importance of evaluating these relationships in longitudinal studies. Nevertheless, depression also mediated the relationship between social networking and OA worsening, indicating that depression may be a potentially modifiable risk factor for the deleterious effects of social networks and the worsening of OA. However, this requires further evaluation in subsequent interventional studies.

Among the limitations of this study, the arbitrary cutoff of a 5% reduction in KOOS adopted to define the worsening of knee OA symptoms may not represent a clinically significant difference and requires further evaluation. While the high dropout rates recorded in this study were comparable to those of similar studies, such as the Framingham Osteoarthritis Study, in which only 60.4% of participants underwent a follow-up assessment,[38] the sample size within this project was limited by a large-scale funding cut that occurred 1 year after study commencement, leading to the cessation of recruitment in favor of serial follow-up with the intention of employing the findings on recruitment and follow-up rates as a pilot cohort for future OA studies. As a result, our ability to statistically adjust for confounders was limited by the low absolute number of individuals with worsening OA. Additionally, knee radiographs were unavailable to all participants due to radiation protection and consent issues, as X-rays were taken based on clinical indications. Handgrip strength measurements were obtained in favor of quadriceps strength owing to the unavailability of specialist equipment at our center, and acquiring it was time-consuming.[39] The use of mean rather than maximum handgrip strength accounted for fatiguability.

Nevertheless, the role of psychosocial determinants of health in determining the progression of knee OA evaluated in this study will contribute to future larger prospective and intervention studies. Whether social networks can be modified through psychological and physical interventions, and if this, in turn, will retard the progression of knee OA, must be established.

In conclusion, social network in individuals aged ≥ 65 years was associated with the subsequent worsening of knee OA, as determined using the KOOS. However, this was accounted for by differences in depression scores, suggesting that psychological interventions may be indicated for the improvement of social networks in older adults, which, in turn, could lead to the prevention of OA progression by enhancing social networks. Interventions to enhance social networks should be considered as part of the non-pharmacological management of patients complaining of worsening knee OA symptoms. Our findings will optimize power calculations and design of future larger prospective studies.

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CONFLICT OF INTEREST

The researchers claim no conflicts of interest.

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AUTHOR CONTRIBUTIONS

Conceptualization, MPT; Data curation, TGJ, MPT; Funding acquisition, MPT; Investigation and Methodology, SCHL, JLMY, TYW; Supervision, KSH, TGJ, SM; Writing-original draft, TGJ, MPT; Writing-review & editing, KSH, TGJ, SM.

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Deep Vein Thrombosis in a Patient with Negative Age-Adjusted D-Dimer Level

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D-dimer level, along with a clinical probability tool that uses the Wells score, is commonly used to exclude deep vein thrombosis (DVT). Age-adjusted D-dimer values are routinely used in clinical practice to increase the negative predictive value and avoid unnecessary Doppler ultrasound imaging. We describe a patient with a low pre-test probability of DVT upon admission and a negative D-dimer level based on age-adjusted values who was later diagnosed with DVT. Our experiences with this case highlight that the geriatric population is unique and, at times, frail.

Key Words: Venous thrombosis, Fibrin fragment D, Ultrasonography, Doppler

INTRODUCTION

Deep vein thrombosis (DVT) is a common diagnosis encountered in the hospital. The Centers for Disease Control and Prevention (CDC) reported an estimated 900,000 cases of venous thromboembolism each year in the United States with 60,000–100,000 deaths. Among these cases of mortality, 25% present with sudden death as the first symptom of pulmonary embolism (PE), for which DVT is a risk factor.[1] PE is a common clinical problem in geriatric populations with immobility secondary to various reasons.[2] Most clinicians follow a diagnostic algorithm that starts with the determination of the clinical pre-test probability (PTP) based on D-dimer levels. The Wells score and modified Wells score are commonly used and widely studied to determine PTP,[3,4] as summarized in Fig. 1. In patients with low PTP in the Wells test or unlikely results in the Modified Wells, the use of D-dimer assessment to exclude DVT is recommended, with a conventional D-dimer cutoff value of < 500 ng/mL.[5] However, D-dimer levels increase with age, hampering the specificity of D-dimer-based assessments in older patients. Using a higher D-dimer cutoff in older patients improves the diagnostic utility and specificity. One meta-analysis of 13 cohorts (12,497 patients) comparing the specificity of conventional D-dimer cutoff values (< 500 ng/mL) to age-adjusted values—defined as age (year) × 10 ng/mL for patients aged > 50 years—showed that the specificity of the conventional cut-off value decreased with increasing age, from 57.6% (95% confidence interval [CI], 51.4%–63.6%) in patients aged 51–60 years to 39.4% (95% CI, 33.5%–45.6%), 24.5% (95% CI, 20.0%–29.7%), and 14.7% (95% CI, 11.3%–18.6%) in those aged 61–70 years, 71–80 years, and > 80 years, respectively. Age-adjusted cut-off values revealed higher specificities for all age categories—62.3% (95% CI, 56.2%–68.0%), 49.5% (95% CI, 43.2%–55.8%), 44.2% (95% CI, 38.0%–50.5%), and 35.2% (95% CI, 29.4%–41.5%), respectively. The sensitivities of the age-adjusted cut-offs remained > 97% in all age categories.[6] If DVT is not ruled out based on PTP and D-dimer levels, compression ultrasonography (CUS) with Doppler of the whole leg is the diagnostic test of choice in patients with suspected DVT. Using the ultrasound probe pressure, the presence of a thrombus is diagnosed by demonstrating the noncompressibility of the imaged vein. The veins that can be assessed for compressibility are the proximal (e.g., common femoral, femoral, and popliteal) and distal (e.g., peroneal, posterior, anterior tibial, and muscular) veins. The risk of embolization is higher in proximal than in distal DVT, and > 90% of acute

Clinical feature	Score
Active cancer (treatment ongoing or within the previous six months or palliative)	1
Paralysis, paresis, or recent plaster immobilization of the lower extremities	1
Recently bedridden for more than three days or major surgery, within four weeks	1
Localized tenderness along the distribution of the deep venous system	
Entire leg swollen	1
Calf swelling by more than 3 cm when compared to the asymptomatic leg (measured below tibial tuberosity)	1
Pitting edema (greater in the symptomatic leg)	1
Collateral superficial veins (nonvaricose)	1
Alternative diagnosis as likely or more likely than that of deep venous thrombosis	-2
Score	
High probability	3 or greater
Moderate probability	1 or 2
Low probability	0 or less
Modification:	
This clinical model has been modified to take one other clinical feature into account: a previously documented deep vein thrombosis (DVT) is given the score of 1. Using this modified scoring system, DVT is either likely or unlikely, as follows:	
DVT likely	2 or greater
DVT unlikely	1 or less

Fig. 1. Wells scoring system.

PE arises from the proximal veins.[7] The Wells score has been validated in outpatient and emergency department settings; however, a study evaluating the Wells score for inpatients showed that it performed only slightly better than chance for the discrimination of DVT risk in hospitalized patients. The Wells score showed a higher failure rate and lower efficiency in the inpatient setting compared to reports in the outpatient literature. Therefore, risk stratification based on the Wells score is not sufficient to rule out DVT or to influence management decisions in inpatient setting.[8] This brings up the argument for hospitalists to decide how to use D-dimer measures and how to interpret PTP and D-dimer levels without anchoring bias from emergency departments or admitting providers.

CASE REPORT

An 85-year-old Spanish-speaking woman with a medical history of essential hypertension and diastolic congestive heart failure (CHF) and a questionable history of remote DVT after giving birth to her son presented to the emergency department (ED) for further evaluation of hypertension and bilateral lower extremity edema that had persisted for approximately 2 weeks. The review of the electronic medical records indicated that the patient had been admitted to the hospital 3 months prior with similar complaints. An echocardiogram performed at that time revealed mild diastolic dysfunction and otherwise normal findings. The patient was discharged on routine medications, including amlodipine (5 mg daily), losartan potassium (50 mg daily), and furosemide (20 mg daily), and counseled on reducing salt intake as dietary noncompliance was the reported main reason for the swelling. Since her last admission, the patient had been started on losartan/hydrochlorothiazide (100 mg/12.5 mg) daily when she visited Mexico, and the furosemide was discontinued. In the ED, the patient's workup was significant for hyponatremia, with a sodium level of 127 mEq/L and normal renal and liver function profiles. The patient's result was negative for troponin, and the brain natriuretic peptide (BNP) concentration was 84 pg/mL. The patient's vital signs included the following: blood pressure 164/84 mmHg; pulse 62 beats/minute; temperature 98.1°F; respiratory rate 16/minute; and oxygen saturation (SpO_2) 98% on room air. Chest radiography was negative for the acute process, and the electrocardiogram findings were normal. The physical examination was unremarkable except for 2+ pitting bilateral edema. In the ED, the patient was administered an intravenous dose of furosemide and was admitted for hyponatremia and lower extremity swelling. The patient's sodium level normalized with fluid restriction, and hydrochlorothiazide was discontinued over the next 2 days. Losartan was continued and enoxaparin (40 mg) was initiated for DVT prophylaxis. One dose of furosemide reduced the swelling. Upon admission, the patient's lower extremity swelling was thought to be secondary to the history of diastolic CHF, dietary noncompliance, and the contribution of amlodipine. The patient's D-dimer level was 0.72 μg/mL fibrinogen equivalent units (FEU) (reference range: 0.00–0.50 μg/mL FEU), which was a negative finding based on the age-adjusted cutoff. The next day, the patient mentioned that along with bilateral lower extremity edema, mild left calf pain was also present, which the patient was not able to further characterize and felt was mild and insignificant. A detailed history at that point indicated that the patient had come to the United States from Mexico approximately 2 months before. The patient denied having experienced any recent trauma, surgery, or hospitalization and also denied a family history of clotting disorders. Regarding the remote history of DVT, the patient mentioned a clot in the left leg that had required surgery after giving birth; however, the patient did not remember ever being on blood thinners and could not provide any other details of the surgery. On examination, the patient had bilateral lower extremity swelling, measuring 15 cm in the right leg and 16 cm in the left leg. Tenderness in the left leg was also present, which the patient denied upon admission to the ED. More swelling was observed in the right ankle than in the left ankle; otherwise, the swelling was bilaterally similar, as shown in Fig. 2. Although the patient's D-dimer level was 0.72 μg/mL FEU, given the clinical picture without evidence of true heart failure to explain the lower extremity swelling and no other reason to explain the pain, we ordered CUS, which revealed occlusive DVT inferiorly at the trifurcation of the left popliteal vein, as shown in Figs. 3 and 4. The patient was initiated on a heparin drip and switched to apixaban upon discharge. On admission and during the hospital stay, the patient denied any shortness of breath, chest pain, cough, or blood-tinged sputum. Given that the patient had no symptoms of PE such as dyspnea, chest pain, or cough; normal chest X-ray and negative troponin findings; and normal BNP levels, in addition to CUS

Fig. 2. Lower extremity picture on day 2 of admission.

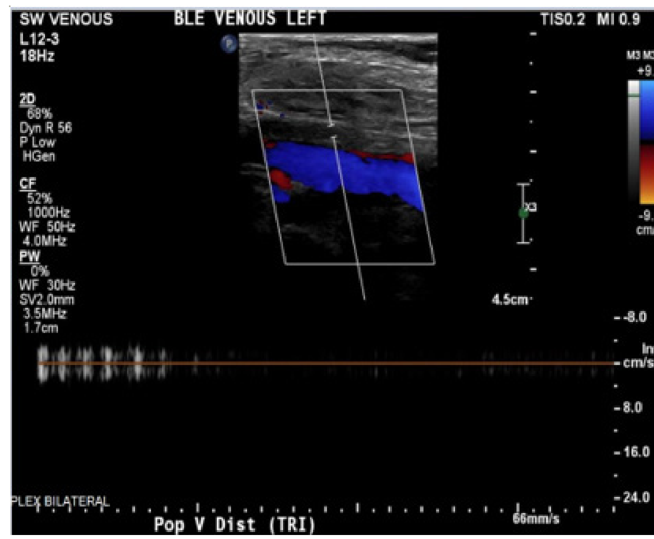

Fig. 3. Doppler image showing no flow at popliteal trifurcation (anterior tibial vein in image).

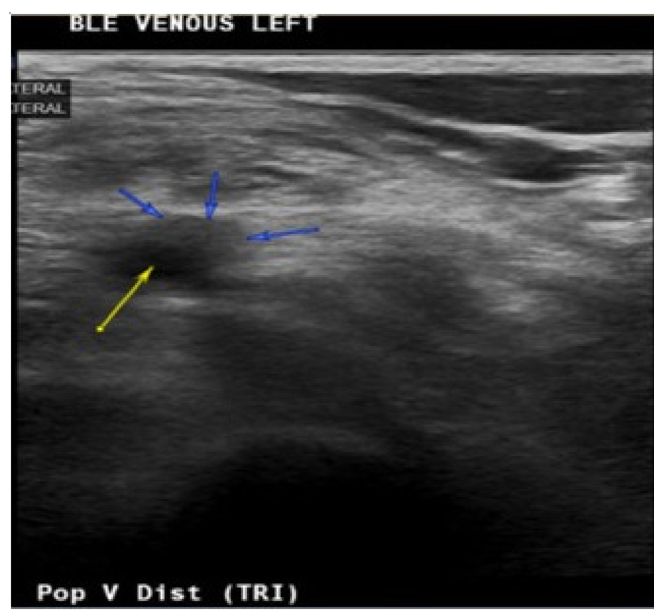

Fig. 4. The yellow arrow shows the popliteal artery, and the blue arrow shows a noncompressible vein filled with echogenic material representing thrombus at popliteal trifurcation.

showing distal DVT, which is a less common cause of PE, we decided not to perform chest computed tomography angiography (CTA) because the likelihood of PE was low, the cost of CTA was prohibitive for the patient, and the findings would not change management of this case. Informed consent was obtained.

DISCUSSION

Based on our patient's presentation in the ED and upon admission, the working diagnosis of the lower extremity swelling was multifactorial, including diastolic CHF, dietary noncompliance, and amlodipine use. The patient had no history of active cancer, paralysis, paresis, or recent immobilization and had not recently been bedridden for >3 days or undergone major surgery within 4 weeks. The patient had traveled from Mexico to the United States 2 months prior. The bilateral leg swelling showed a difference of <3 cm. The patient had superficial collateral veins bilaterally. However, an alternative diagnosis as likely as or more likely than that of DVT was possible, and it negated two points on both Wells and Modified Wells scores; therefore, PTP showed a low probability or was unlikely. Therefore, her D-dimer level was negative based on age-adjusted limits, and in clinical practice, CUS was not needed. However, our experiences with this case highlight the fact that even though the patient's left calf pain was nonspecific, reevaluation of the odds of DVT at follow-up is important. Moreover, in this kind of presentation, with multiple possible explanations for the symptoms, a negative D-dimer finding might prevent us from considering the possibility of DVT due to an anchoring bias. Amlodipine is associated with pedal and lower extremity edema, which is a common dose-dependent side effect if taken for >4 weeks.[9] The patient's history of uncontrolled hypertension, diastolic heart failure, and dietary noncompliance were all likely reasons for the presentation. Therefore, even after adding isolated left leg pain, it can be argued that the modified Wells score changed. If multifactorial reasons cannot explain symptoms such as the left leg pain in the present patient, D-dimer levels should not be considered in the diagnosis, and on a follow-up visit, patients should undergo CUS testing to rule out DVT. This case emphasizes the importance of not having an anchoring bias and keeping an open mind when evaluating a patient when a new complaint arises during independent history-taking or when patients mention small non-significant complaints during their hospital stay. Silveira et al. reported that the usefulness of the Wells scoring system has not been validated; additionally, more data are needed to determine when to stop using the Wells scoring system after a patient is admitted.

In conclusion, DVT is associated with local and life-threatening complications, including death from PE. Proximal DVTs are major, life-threatening complications. The subjective differences among calculators must be considered when determining the PTP for DVT. However, the use of the Wells score in inpatient settings should be questioned. This case also highlights that anchoring bias can occur if we do not change our interpretation of D-dimer after more information in terms of history or diagnosis becomes clearer on the days following admission, as usually upon admission, patients are managed based on a working diagnosis.

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AUTHOR CONTRIBUTIONS

The author performed the design and implementation of the proposed method and read and approved the final manuscript.

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Letter to the Editor
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Short Physical Performance Battery Cutoff Points Using Clinical Outcomes for At-Risk Older Adults in Singapore: An Exploratory Study

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To the Editor:

The Short Physical Performance Battery (SPPB) is a reliable and valid measure of physical performance that examines three components of lower extremity function: standing balance, gait speed, and repeated sitting-to-standing, with scores ranging from 0 (worst) to 12 (best).[1)] Poor physical performance based on the SPPB is associated with adverse outcomes such as increased fall risk, functional and cognitive impairment, hospital readmission, and all-cause mortality. The SPPB is an effective screening tool for frailty and sarcopenia[2)] in older persons, with acceptable sensitivity and specificity.[3)] Because of the increasing prevalence of frailty and sarcopenia with population aging, automated versions have been developed using modern sensor technologies to facilitate the scalability and widespread use of the SPPB for the assessment of physical performance in community and clinical settings to enable earlier identification and timely interventions in at-risk older adults.[4)]

Depending on the clinical indication, recommendations differ regarding SPPB cutoff values. The European Working Group on Sarcopenia in Older People 2 recommends a cutoff of ≤ 8,[5)] while the Asian Working Group for Sarcopenia 2019 (AWGS-2019) recommends a cutoff of ≤ 9,[6)] whereas the cutoff that maximized both sensitivity and specificity for the frailty phenotype was ≤ 8 points for men and ≤ 7 for women.[2)] Moreover, the SPPB may exhibit a ceiling effect, with one study reporting that ≥ 20% of participants attained the maximum score of 12.[7)] The ceiling effect is more commonly observed in community studies that include higher functioning and younger participants and less likely in studies involving older adults.[2,7,8)] Therefore, the reference values for the SPPB are outcome- and population-dependent.

The Yishun Study in Singapore recently recommended an optimal cutoff of ≤ 11 for both sexes to discriminate sarcopenia in healthy older persons aged ≥ 60 years. The study limitations suggest caution in the widespread adoption of the higher cutoff, including cutoffs derived based on sarcopenia diagnosis instead of clinically relevant outcomes, healthy community-dwelling participants (mean SPPB score of 11.4 in sarcopenia) with possible spectrum bias, and fair-poor diagnostic performance of the SPPB for sarcopenia (area under the curve [AUC], 0.54–0.64). As this cutoff is much higher than previous cutoffs, the adoption of the more stringent ≤ 11 cutoff may inappropriately increase case detection of older persons who are otherwise not at elevated risk of adverse outcomes.

Thus, we conducted an exploratory study to determine the diagnostic performance and optimal cutoffs of the SPPB for clinically meaningful outcomes (functional ability, social activity, frailty, and gait speed) in an at-risk population of older adults attending a fall clinic compared to healthy controls. This was a secondary analysis using data from two earlier studies: the eSPPB kiosk validation study involving predominantly pre-frail patients attending a tertiary falls clinic (n = 37),[4)] and healthy community-dwelling older persons from the "Longitudinal Assessment of Biomarkers for Characterization of Early Sarcopenia and Predicting Frailty and Functional Decline in Community-dwelling Asian Older Adults" (GeriLABS) longitudinal cohort study (n = 200).[9)] We excluded participants with incomplete SPPB data or those who did not consent to the use of their data for future studies. Thus, our final sample comprised 165 community-dwelling older adults from the Falls Clinic (n = 27; 73% of the original study) and the GeriLABS study (n = 138; 69% of the original study). We used pre- specified validated cutoffs of clinical outcome measures which are associated with adverse outcomes, namely, the Lawton instrumental activities of daily living (IADL) < 21,[10)] Frenchay Activities Index (FAI) < 31,[11)] pre-frailty/frailty defined by FRAIL scale > 0,[9)] and gait speed < 0.8 m/s.[12)] Using receiver operating characteristic (ROC) curves generated for different outcomes, we determined the optimal cutoff values using the Youden Index and corresponding AUC. Based on the ROC cutoffs, we performed crosstabulation to derive the corresponding values for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), from which we determined the optimal cutoff for the SPPB. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY, USA). All statistical tests were two-tailed, and the level of statistical significance was set at 5%.

The GeriLABS cohort was younger (mean age: 67.3 ± 7.3 vs. 77.1 ± 6.9 years), more robust (mean FRAIL score: 0.17 ± 0.45 vs. 1.2 ± 0.83), and had a higher mean SPPB score (11.6 ± 0.79 vs. 7.0 ± 3.2, $p < 0.001$) compared to the Falls Clinic group. The SPPB showed excellent discriminatory performance for reduced functional ability (IADL < 21: AUC = 0.872, 95% confidence interval [CI] 0.757–0.986), and the optimal SPPB cutoff of ≤ 8 yielded a sensitivity of 73.7% and a specificity of 96.6%. The SPPB showed fair performance for social activity (FAI < 31: AUC = 0.586, 95% CI 0.491–0.680) with an optimal cutoff score of ≤ 9 (sensitivity of 25.0%, specificity of 89.9%, PPV of 56%, NPV of 70%). Regarding the assessment of pre-frailty/frailty, the SPPB showed good discriminatory performance (FRAIL > 0: AUC = 0.762, 95% CI 0.664–0.860) using an optimal cutoff score ≤ 9 (sensitivity of 47.5%, specificity of 95.2%, PPV of 76%, NPV of 85%). Finally, the SPPB showed excellent performance for gait speed < 0.8 m/s (AUC = 0.972, 95% CI 0.945–0.998) for an optimal cutoff score of ≤ 9 (sensitivity of 81.5%, specificity of 97.8%, PPV of 88%, NPV of 96.4%) (Table 1).

The excellent discriminatory performance for functional ability, pre-frailty/frailty, and gait speed in our exploratory study supports the utility of the SPPB for assessing physical frailty and sarcopenia in at-risk community-dwelling older persons. Social activity is a complex phenomenon attributable to personal, social, and environmental factors beyond lower limb physical performance, which may explain the comparatively lower diagnostic performance of FAI in our study. Although the sensitivity range of the SPPB is quite broad (from 21.4% to 81.5%), it is highly specific (93.6%–97.8%). Our findings are similar to those of the Yishun Study, wherein the SPPB showed poor-to-moderate sensitivity but was highly specific for assessing sarcopenia.[13] Thus, while the SPPB has overall good diagnostic performance for frailty and sarcopenia in at-risk community-dwelling older adults, it is better at "ruling in" true-positive cases than ruling out false-negative cases in the screening process. While an earlier Australian study reported that the SPPB has high sensitivity but low specificity with moderate (AUC = 0.644–0.770) value in diagnosing sarcopenia, this was in the context of a lower cutoff (≤ 8) for the assessment of severe sarcopenia.[14]

The optimal SPPB cutoff for clinically meaningful outcomes such as social activity and functional ability for identification of community-dwelling older persons at risk of sarcopenia and physical frailty for older adults in Singapore is ≤ 9, which is consistent with the AWGS-2019 recommendation and lower than the ≤ 11 cutoff in the Yishun Study. The participants in the Yishun Study were younger and more robust, whereas our study included predominantly pre-frail, at-risk patients from a fall clinic. Because ROC-derived cutoff points may not account for spectrum bias,[15] this further supports the idea that reference values should be selected based on specific settings and patient characteristics. Adopting an appropriate cutoff score for the SPPB, which is predictive of clinically meaningful outcomes, can avoid overdiagnosis and unnecessary use of resources while fulfilling the purpose of identifying patients who would benefit from early intervention.[8]

Taken together, the results of this study demonstrate that SPPB cutoff values should consider population characteristics and clinically meaningful outcomes. In at-risk older adults, an SPPB cutoff score of ≤ 9 yielded good diagnostic performance for the assess-

Table 1. Optimal SPPB reference values using clinically meaningful outcomes

Criteria	Method	Cutoff point	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
IADL < 21	ROC	≤ 8.5	73.7	96.6	-	-
	Crosstab	≤ 8.0	73.7	96.6	73.7	96.6
FAI < 31	ROC	≤ 8.5	21.4	93.6	-	-
	Crosstab	≤ 9.0	25.0	89.9	56.0	70.0
FRAIL > 0	ROC	≤ 9.5	47.5	95.2	-	-
	Crosstab	≤ 9.0	47.5	95.2	76.0	85.0
GS ≤ 0.8	ROC	≤ 9.5	81.5	97.8	-	-
	Crosstab	≤ 9.0	81.5	97.8	88.0	96.4

SPPB, Short Physical Performance Battery; IADL, Lawton instrumental activities of daily living; FAI, Frenchay Activities Index; FRAIL, "Fatigue, Resistance, Ambulation, Illness, Loss of weight" scale; GS, gait speed; PPV, positive predictive value; NPV, negative predictive value; ROC, receiver operating characteristic curve; Crosstab, crosstabulation.

ment of frailty, despite low-to-moderate sensitivity for social activity and pre-frailty/frailty. Owing to the small sample size of our exploratory study of at-risk compared to healthy older adults, further studies with larger sample sizes that examine the predictive validity of SPPB cutoffs for longitudinal adverse outcomes are needed to corroborate our findings.

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AUTHOR CONTRIBUTIONS

Conceptualization, HHCH, DZY, JK, NHI, WSL; Data curation, HHCH, DZY, CNT; Investigation, HHCH, DZY, JK, NHI, WSL; Methodology, HHCH, DZY, JK, NHI, WSL; Project administration, CNT; Supervision, WSL; Writing-original draft, HHCH; Writing-review and editing, HHCH, DZY, NHI, WSL.

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Retraction: Denosumab's Therapeutic Effect for Future Osteosarcopenia Therapy: A Systematic Review and Meta-Analysis

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The following article "Denosumab's Therapeutic Effect for Future Osteosarcopenia Therapy: A Systematic Review and Meta-Analysis (https://doi.org/10.4235/agmr.22.0139)" published in *Annals of Geriatric Medicine and Research* in March 2023 has been retracted at the request of the authors.

After publication, concerns were raised about several methodological flaws which could affect the conclusion of the study. The authors were informed and acknowledged several shortcomings in the results section. Authors have tried to revise the honest errors but apologized for not being able to respond to queries and therefore, the authors wish to retract the article from publication.

As such, the editorial board of AGMR have agreed on retraction of the article to ensure the integrity of the scholarly record.

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- A complete title page should be submitted separately from the main document file, and the latter should contain no information that identifies the author or the author's institutional affiliation.
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The manuscript sections should be presented in the following order: Cover Letter, Title Page, Abstract and Keywords, Introduction, Materials and Methods, Results, Discussion, Acknowledgements, References, Tables, and Figure Legends. Provide only one table or figure per page. Table 1 shows the recommended maximums of manuscripts according to publication type; however, these requirements are negotiable with the editor.

Table 1. Recommended maximums for articles submitted to AGMR

Type of article	Abstract (word)	Text (word)[a]	Reference	Table & figure
Original article	Structured[b], 250	3,500	50	7
Review	150	6,000	unlimited	7
Case report	150	1,500	20	7
Editorial	No	1,200	15	7
Letter to the editor	No	1,200	15	1

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[a]Maximum number of words is exclusive of the abstract, references, tables, and figure legends.
[b]Background, methods, results, and conclusion.

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Reference Style

- Journal article:
  1. Oh TJ, Song Y, Moon JH, Choi SH, Jang HC. Diabetic peripheral neuropathy as a risk factor for sarcopenia. Ann Geriatr Med Res 2019;23:170-5.
- Book:
  2. Fillit H, Rockwood K, Woodhouse K, Young JB. Brocklehurst's textbook of geriatric medicine and gerontology. 8th ed. Philadelphia, PA: Elsevier; 2016.
  3. Korea National Statistical Office. Annual report on the cause of death statistics, 2015. Daejeon: Korea National Statistical Office; 2016.
- Book chapter:
  4. Phillips SJ, Whisnant JP. Hypertension and stroke. In: Laragh

JH, Brenner BM, editors. Hypertension pathophysiology, diagnosis, and management. 2nd ed. New York, NY: Raven Press; 1995. p. 465-78.

- Website:

5. AMA: helping doctors help patients [Internet]. Chicago, IL: American Medical Association; c2019 [cited 2019 Dec 22]. Available from: http://www.ama-assn.org.

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Annals of Geriatric Medicine and Research
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AGMR 2023

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