**Abstract**  Grip strength is a well-known indicator of muscle strength. The trajectories of grip strength with increasing age refer to the aging and development process of muscle strength over one’s life span. The levels of muscle strength needed to perform activities of daily living or to prevent older people from developing disabilities are serious geriatric issues. Grip strength has been shown to decline with aging and to be a predictor of the development of geriatric problems, which suggests the lifelong management of grip strength has great potential for the promotion of healthy aging. The focus of this short review was to examine grip strength as an indicator of geriatric issues and to clarify the role of grip strength in relation to healthy aging.

**Keywords**: grip strength, aging, life course, community-dwelling individuals

**Introduction**

Muscle strength is vital for performing activities of daily living. Particularly in rapidly aging societies, the importance of muscle strength in regard to understanding the aging process and preventing the loss of functional capacity and the development of geriatric syndromes has been increasingly emphasized. Grip strength has been used extensively as an indicator of muscle strength. A simple and established method for measuring grip strength could enable broad observational data to be collected from nationwide surveys and community-based health checkups. The literature has provided a wide age range reference value and outlined aging patterns in relation to grip strength. On the other hand, data have shown diverse age-related changes in grip strength and associated factors; therefore, the “normal/true” aging process for grip strength over one’s life-span, how much grip strength is needed in old age, and the determinant factors of grip strength remain as a challenge.

Muscle strength in old age has been well documented in the literature; however, few studies have assessed the actual meaningfulness of grip strength in relation to healthy aging. Therefore, the aims of this short review were as follows: 1) to examine grip strength as a predictor of geriatric problems; and 2) to clarify the role of estimating grip strength for the promotion of healthy aging through a summary of previous epidemiological studies and results from 2267 adult participants (age range, 40-79 years at baseline) in the National Institute for Longevity Sciences - Longitudinal Study of Aging (NILS-LSA).

Although a variety of useful functional indicators such as walking speed have been identified in this research area, the present short review focuses primarily on grip strength.

**Availability as an indicator of muscle strength**

Grip strength, which represents hand strength, has been adopted as a useful indicator of muscle strength. Since grip strength is strongly related to lower extremity muscle strength, as well as overall body strength, it has been referred to as an indicator of muscle strength for the entire body. Although several methods for measuring grip strength have been utilized over time, the standard techniques are quite simple, so grip strength has been measured across wide age groups, including preschool children and older people in institutions. The advantage of grip strength is that it is especially effective in epidemiological studies investigating public health issues in cooperation with community-dwelling participants. To prevent injuries and the worsening of health conditions, some individuals should be excluded from muscle strength tests in accordance with the related health risks. In addition, some individuals may refuse to participate in such tests if they are seen as excessively difficult or physically demanding. High refusal or dropout rates are usually discussed in the limitations of related research because such loss of data may affect study results. In the NILS-LSA, grip strength, knee extension strength, and knee extension power were considered indicators of muscle function. However, more dropout rates were observed in follow-up studies for knee extension strength and power than for grip strength because many of the participants who had serious pain, physical injury, or illness could not perform the measurements. Although lower muscle function such as knee extension strength is considered an important determinant factor of mobility, an under-
estimated age-related decline in knee extension strength should be considered because of the possible bias associated with healthier/stronger people. Grip strength could therefore be the most acceptable indicator for general muscle strength in a broad range of community-dwelling individuals.

Validity as a predictor of geriatric concerns

Maintaining muscle strength in older adults is necessary for enhancing quality of life. Impairment of muscle function in considered to lead to disability and a loss of independence. Grip strength has been reported to predict geriatric syndromes associated with disability among older people, as well as mortality. Sarcopenia, which is defined as the age-related loss of muscle mass, is one of the main geriatric syndromes among older people. Although sarcopenia was originally estimated based on appendicular skeletal muscle mass, the current criteria of sarcopenia remains varied. The current consensus in Asia and Europe regarding the definition of sarcopenia includes a loss of grip strength and/or walking speed in the criteria. In addition, physical frailty, which is considered a high-risk factor for physical disability, hospitalization, and mortality, is characterized by weakness (grip strength) as part of its definition. The prevalence of sarcopenia and frailty in the NILS-LSA using the current criteria have been previously reported in this journal. The results from those studies described the number of people associated with each criterion of muscle mass, strength, and performance, which could represent key data underlying the conditions of sarcopenia and frailty in the Japanese population.

A shift in criteria may be associated with age-related changes in muscle quality. Muscle quality decreases in accordance with motor unit loss and fat infiltration into the muscle with aging; therefore, muscle mass may not sufficiently correlate with muscle function in later life. This would be supported by our finding in a previous study that although older people had the same amount of arm muscle mass as middle-aged people, they also had significantly lower grip strength. Dynapenia, a term used to refer to the age-associated loss of strength, has been used to clarify differences between muscle mass and function. From the viewpoint of these differences, grip strength may more accurately predict the risk of developing geriatric problems among older adults.

Grip strength cut-off values

Outcome-based cut-off values for grip strength are needed to predict the risk of geriatric problems and estimate the adequate level of functional capacity at each age. In Japan, the cut-off points of 26 kg in men and 18 kg in women for preventing geriatric syndromes, as suggested by the Asian Working Group for Sarcopenia, may be the most widely accepted. At the threshold point of impaired physical capacity, lower limits are more serious in women. The Foundation for the National Institutes of Health Sarcopenia Project criteria defined grip strength
of less than 16 kg in women as "weak"\textsuperscript{46}. For maintaining mobility, which is the most basic ability for daily living, the grip strength cut-off value for self-reported difficulties was 19 kg in a British cohort\textsuperscript{1} and 20 kg (body mass index: 20-24.9 kg/m\textsuperscript{2}) for difficulties in walking (0.5 km) or stair climbing in a Finnish cohort\textsuperscript{47}.

In our previous study, we reported that the grip strength cut-off value was a motivating factor for exercise. In older women who had never participated in regular exercise from adolescence to middle adulthood, grip strength was significantly associated with starting exercise at an older age, regardless of lifestyle and health conditions. Women who had grip strength of 20 kg or more were 2.7 times more likely to start exercise at an older age\textsuperscript{49}. Our findings indicated that maintaining grip strength was associated with becoming more physically active in old age; these results were supported by a recent longitudinal study reporting that the maintenance and/or improvement of grip strength was associated with being physically active, whereas the opposite association was unclear\textsuperscript{49}. These findings suggest the effectiveness of maintaining grip strength for promoting healthy aging, especially in women.

However, the threshold point of the decline rate in grip strength may be more important for men because a rapid decline in muscle strength could not only inhibit physical function, but also affect social-psychological aspects of aging. The combination of a loss of grip strength with a low level of grip strength has also been shown to predict mortality in later life in men\textsuperscript{50}. However, little is known about the rate of decline in grip strength in later life among men; therefore, this issue should be examined in future research.

\textbf{Determinant factors of grip strength: life course approach}

Although physical activity is a leading factor associated with the level of grip strength\textsuperscript{41}, the association between physical activity and grip strength in later life has not always been clear in observational studies\textsuperscript{51,52}. The risk factors associated with a decline in grip strength seem to be more closely associated with lifestyle (e.g., smoking and stress) in women and with physical characteristics (e.g., mean arterial pressure, physical activity and chronic disorders) in men\textsuperscript{53}. Based on 22-year follow-up data, Stenholm et al. reported that long-term lifestyle factors, including physical activity, weight change, and smoking status, and physical health factors, including cardiovascular disease and diabetes, were strongly associated with a decline in grip strength in old age\textsuperscript{53}. Therefore, comprehensive healthy lifestyle components, including level of physical activity, may determine grip strength.

Childhood and adolescence are considered the most important periods for establishing a healthy lifestyle. In our previous study, we reported that adolescent exercise was associated with both participating in leisure-time physical activity and higher grip strength in later life\textsuperscript{52}. Recently, a "life course approach," which is conceptualized as "the study of the long-term effects of physical or social exposure - during gestation, childhood, adolescence, young adulthood and later adult life - on later health or disease risk,"\textsuperscript{55} has progressed in geriatric research. According to this concept, a partial approach for each age period as well as an overall/life course approach may be needed in order to fully understand healthy aging and the aging process. Grip strength could therefore play a key role in the determination of physical capacity throughout the life course.

\textbf{Conclusion}

Previous studies on grip strength have provided robust evidence that higher grip strength is associated with a lower risk of developing geriatric problems; they have also illustrated age-related changes in grip strength across the life-span. Long-term changes in grip strength are associated with lifestyle- and health-related conditions, as characterized by the expression "grip strength is a crude but effective will-to-live meter"\textsuperscript{55,56}. The lifelong management of grip strength may promote healthy aging in super-aging societies by providing a better understanding of age-related changes in individuals and motivating diverse populations to maintain higher levels of muscle strength.

\textbf{Conflict of Interests}

The author declare that there is no conflict of interests regarding the publication of this article.

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