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*Editorial*

# Frailty in an aging society and the applications of robots

**Izumi Kondo, MD, PhD**[1]

[1]National Center for Geriatrics and Gerontology

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## The current situation of Japan's aging population

Since 1950, the Japanese population of elderly people aged 65 and older (hereafter referred to as "older adults") has steadily increased, surpassing 30 million people in 2012. As of September 15, 2018, the number of older adults was estimated at 35.57 million [1]. Older adults comprised 28.1% of the total population at that time, an increase of 0.4% compared to the previous year's 27.7%, and the percentage of older adults continues to increase. According to estimates by the National Institute of Population and Social Security Research, the percentage of older adults is expected to keep rising, and by 2040, when those born during the second baby boom will be 65 or older, older adults will comprise 35.3% of the total population. In contrast, the working-age population is expected to comprise 69.51 million people in 2029, dropping below 70 million, and estimates predict that it will shrink to 45.29 million by 2065 [2]. While in 1950 there were 12.1 people of working age (ages 15 to 64) for each person aged 65 or older, that figure had dropped to 2.3 per older adult in 2015. The percentage of people of working age is expected to continue decreasing and is predicted to reach 1.3 people for each older adult by 2065. As the older adult population rapidly expands and the working-age population continues to shrink, we will see a further emergence of problems such as rising medical care costs for older adults, higher social security benefit payments, a more severe shortage of care workers, and greater difficulty in ensuring the necessary financial resources to implement measures and policies targeting older adults [3].

Correspondence: Izumi Kondo, MD, PhD
National Center for Geriatrics and Gerontology, 7−430 Morioka-cho, Obu, Aichi 474−8511, Japan.
E-mail: ik7710@ncgg.go.jp
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## The need for robots in an aging society

With society undergoing rapid aging as described above, three primary issues need to be addressed: 1) dementia, 2) frailty, and 3) end-of-life care. With respect to these issues, and frailty in particular, given that labor resources will decrease as society ages, the introduction of robots that can help older adults maintain their lifestyle and possibly even improve and sustain everyday functioning will become essential so that people can look forward to a healthy life expectancy. Surveys conducted with the families of older adults indicate that people have high expectations for robots, particularly in terms of taking over the burden of caregiving [3]. Moreover, studies examining the need for robots in the everyday life of older adults have shown that although people currently do not view the use of robots as particularly desirable, respondents felt that in the near future, particularly considering their own decreased functionality with aging, older adults will begin using robots [4]. Even assuming that caregiving will not be necessary, robots will be needed in order to provide means of mobility, keep people healthy, maintain safety, and facilitate social interaction, among other functions. To fulfill such needs, however, robots must be able to learn and modify their actions in response to the owner's needs and wishes[5]. Robots are already demonstrating their usefulness in fields such as cleaning, surgery, and surveillance, but have not yet reached the point where they can fulfill such needs as those described above.

## Falling and frailty

Falling is almost inevitable, given that we live our life in a posture of resisting gravity. For humans in particular, who perform bipedal locomotion, the likelihood of falling is increased by the fact that our base of support, which helps us maintain our balance, is narrow in relation to our high center of gravity. As we get older, our reaction time slows [6] and we lose muscle strength [7], further increasing the likelihood of falling. For younger people, falls are not likely to result in serious injury, but older adults are less able to take proper defensive action to protect themselves against external forces when they fall, raising the risk of serious injuries such as bone fractures or intracranial bleeding. Falling also imposes a psychological burden, and as a result, people become afraid of falling again (fear of falling) [8]. There are a number of factors that affect fear of falling: female gender, physical ability, pain, existing disabilities, lack of a caregiving system, low activity level, and past history of falls. Nonetheless, studies conducted to date indicate that among these, a past history of falls is the primary factor in fear of falling. Fear of falling can reduce the person's willingness to engage in physical movement, leading to an even lower activity level. A lack of physical activity leads to reduced muscle strength, which can adversely affect balance, making falls even more likely to occur [9]. We can easily envision a vicious cycle in which, as we age, we begin to lose our ability to maintain our balance, and then we fall, develop a fear of falling, reduce our physical activity, lose muscle strength, and develop sarcopenia, which further degrades our ability to maintain our balance, and we spiral downwards into frailty. It is necessary to strengthen the ability to maintain our balance and prevent falling. In many cases, rehabilitation exercise programs aimed at improving the ability to maintain balance are made too difficult, and are thus inappropriate for motor learning, or conversely are too easy and fail to keep the patient's interest, adversely affecting their willingness to continue the exercises on a daily basis.

## Efforts to use robots to overcome frailty

When considering ways to break out of the vicious cycle created by balance impairment followed by falling and progressing to frailty, robots offer possibilities for adaptation. We conducted a program using the Balance Exercise Assist Robot (BEAR) jointly developed by Fujita Health University and Toyota Motor Corporation, in which we worked with frail older adults in a local community, and demonstrated that exercises using the robot are expected to produce significantly better outcomes than ordinary exercises [10]. Moreover, among hospitalized patients, most falls occur early on in their hospitalization, but it has been found that the second-highest number of falls occurs at the stage when rehabilitation has helped the patient to recover function and physical activity is increasing [11]. Patients who were temporarily unable to walk because of a stroke, leg fracture, or other condition that impeded walking use a walker for support during rehabilitation and go through a phase when they gradually improve their ability to maintain balance and muscle strength. During this phase, they need assistance or someone to watch over them in order to ensure safety, and robots are being adapted for use during this phase. We are conducting a joint study with Nagoya University in which a fall prevention mechanism (Intelligent Cane Robot) is added to the walking assistance robot used during this phase [12].

To prevent the progression of frailty, patients also need to maintain a sufficient level of activity after they complete their rehabilitation and are discharged. Fear of falling can significantly affect their progress in this phase as well, but the fear can possibly be alleviated by limiting the range of disturbance to the center of gravity in older adults. It has been found that when a person is standing, simply touching an object lightly can reduce instability in the center of gravity [13]. This light touch can be realized by using a lightweight cane, developed jointly with Meijo University, and tests are currently underway using a treadmill provided with a virtual reality environment (Gait Real-time Analysis Interactive Lab: GRAIL) that is being used to assist patients in test walking.

## Summary

The increase in frailty that accompanies aging causes various problems, but by utilizing the properties of robots, this progression of frailty can be prevented, and we believe that as the developed robots reach the production stage, they will also play a useful role in industrial development. Considering that Japan ranks first worldwide in terms of its aging society, and that it is also the global leader in adapting robots to serve the aging population, we can play an important role in achieving sustainable economic growth and a healthy life for older adults.

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