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# Are Japanese Older Adults Rejuvenating? Changes in Health-Related Measures Among Older Community Dwellers in the Last Decade

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## Abstract

During the last three decades, Japan has become one of the world's top countries for longevity, and the increase in average life expectancy is accompanied by a sharp rise in older population 65 years of age and above to ∼28%. This study aimed to examine the changes in major health-related measures, including a physical constitution, physical function, and functional capacity of community-dwelling Japanese older people in the last decade. From the data of 13 longitudinal cohort studies on aging conducted in Japan with a total of 13,441 older subjects, this study analyzed the changes in six indices that are related to health and functioning of the older people; height, weight, body mass index, walking speed, grip strength, and instrumental activity of daily living, between 2007 (±2 years) and 2017 (±2 years). Comparison of data for the two periods between subjects matched for age group and gender evidently showed better health status and a slower decline in most of the health-related measures in 2017 compared to a decade ago. The results of this study indicate that the phenomenon of ''rejuvenation'' is occurring among the new generation of Japanese older adults, and the importance of this older population as a social resource in the super-aged society should be reacknowledged.

**Keywords:** long-term change, physical function, walking speed, grip strength, community dwelling, Japanese older adults

## Introduction

Currently, both Japanese men and women are among the populations in the world with the longest life expectancy. The trend of prolonged longevity has become evident since the 1990s. Although the factors contributing to such prolonged longevity in a population are complex, a phenomenon of improved health level (functioning) as a result of improved physical functions in older people as longevity increases has been observed. This phenomenon has great relevance with respect to the significance of the existence of older people in the super-aging society. It would provide an important insight on whether older people are simply a socially vulnerable group posing a

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burden on the society, or a promising population that serves as an effective resource for the society.

The first author previously reviewed the data of the Longitudinal Interdisciplinary Study on Aging conducted by the Tokyo Metropolitan Institute of Gerontology ''TMIG-LISA'' to analyze the changes in functional capacities of older people living in a rural community during the 10-year period from 1992 to 2002.[1–3] The findings revealed that the older population showed marked improvements (changes toward a favorable direction) in walking speed, grip strength, instrumental activity of daily living (IADL), and other measures related to the health status and functioning as the mean life expectancy was prolonged, suggesting the observation of a phenomenon of ''rejuvenation.''

This study aimed to clarify the changes of the major health-related measures, including physical constitution, physical function, and functional capacity, over the last decade in a representative population of community-dwelling older people in Japan. We report the changes from 2007 to 2017 obtained by performing a pooled analysis of the data measured in 12 longitudinal cohort studies on aging, which are representative of Japan. Furthermore, we compared the decline of these health-related measures in both the 2007 and 2017 cohorts to confirm whether the decline in functional capacity has slowed down, that is, whether the phenomenon of ''rejuvenation'' has occurred. In addition, by supplementing the data of TMIG-LISA, we also discuss the changes in health level of Japanese older adults during the 25 years from 1990.

## Subjects and Methods

### *About Integrated Longitudinal Studies on Aging in Japan*

In 2017, the National Center for Geriatrics and Gerontology launched the ''Integrated Longitudinal Studies on Aging in Japan'' (ILSA-J) with the collaboration of 13 longitudinal cohort studies on aging conducted in older people living in the community.[4–16] The cohorts identified for this research were considered to be representative of the Japanese older population and have relatively high accuracy. The cohort studies included in ILSA-J satisfied the following criteria: being conducted in Japan, including Japanese older adults 65 years of age and above living in the community, observational study on aging using standardized methods of measurement, and has published the study design. The characteristics of the 13 studies are summarized in Table 1.

Except 1 cohort, which was conducted only mail survey,[6] from the data measured in 12 cohort studies, which were compatible to those analyzed in ILSA-J, we selected six variables (height, weight, body mass index [BMI], normal walking speed, grip strength, and IADL) that are the basic and essential measures most commonly used in studies related to physical constitution, physical function, and functional capacity of older people. We stratified the subjects by gender and by 5-year age group in each cohort. For each variable, we collected the data on number of subjects or mean and standard deviation of the measurements for each gender and age group. To examine the changes in the last decade, we selected two longitudinal ''fixed'' time intervals: $2007 \pm 2$ years and $2017 \pm 2$ years. The time interval of $\pm 2$ years was adopted because assessment periods were different among cohorts. For example, one study conducted a survey in 2007, while others conducted surveys between July 2006 and August 2008. Each cohort study as well as ILSA-J was approved by the relevant ethics committee and written informed consent was obtained from all subjects. The ILSA-J protocol was also approved by the Committee of Ethics of Human Research at the National Center for Geriatrics and Gerontology (No. 1174).

### *Study items*

The methodology related to the six variables analyzed in this study was as follows: height (cm) was measured using a gauge, to the nearest 0.01 cm. Weight (kg) was measured using a scale, to the nearest 0.01 kg. BMI ($kg/m^2$) was calculated by dividing weight (kg) by height squared ($m^2$), to the nearest 0.01 $kg/m^2$. Normal walking speed (m/s) was measured by a method recommended in Japan. Basically, two or three trials were performed, and the faster speed was recorded, to the nearest 0.01 m/s. However, there were some differences in the walking distances: 2.4, 5 and 6 m in one study each, and 10 m in two studies in 2007; and 2.4 m in one study, 5 m in seven studies, and 10 m in one study in 2017. Hand grip strength was measured using a Smedley dynamometer. Two trials were performed, and the larger reading was recorded, to the nearest 0.01 kg. IADL was assessed using one of the subscales of the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC; 13 items).[17,18] The subscale related to IADL is ''Instrumental Self-maintenance,'' which contains five items: Can you go out by yourself using bus or train? Are you able to shop for daily necessities? Are you able to prepare meals by yourself? Are you able to pay bills? Can you handle your own banking? A score of 1 is given to a response of ''yes'' and 0 to ''no'' and sum of the scores was calculated. The total score for an individual ranges from 0 to 5.

### *Statistical analysis*

To calculate the pool averages and 95% confidence intervals (CIs) of height, weight, BMI, walking speed, grip strength, and IADL, we performed one-group meta-analyses using the comprehensive meta-analysis software version 3.0.[19] Heterogeneity across studies was assessed by Cochran's $Q$ test and $I^2$ statistic, and was considered to be present when $p < 0.05$. The $I^2$ values of 25%, 50%, and 75% were considered to indicate heterogeneity at low, moderate, and high level, respectively.[20] For each age group (5-year increments), gender, and study year (2007 or 2017), we calculated pooled averages and 95% CIs of height, weight, BMI, walking speed, grip strength, and IADL using random-effects models if heterogeneity was present and fixed-effects models if heterogeneity was absent.[21] Analysis of covariance (ANCOVA) was performed to verify whether there are differences between the secular changes of these health-related measures between the 2007 and 2017 cohorts, which is synonymous with whether the phenomenon of rejuvenation occurred among the community-dwelling older people in the recent cohort. In ANCOVA, we constructed pseudo-microdata from the summary statistics (including mean, standard deviation, and CI)[22–24] for each cohort in the 2007 and the 2017 analyses, and the baseline values of the measurements for each cohort were used as covariance.

Table 1. Characteristics of the Cohort Studies Included in the Pooled Analysis

| | 2007 | | | | | | | | 2017 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cohort* | *Investigation period* | *No. of subjects* | *Gender (women %)* | *Age (mean ± SD)* | *Physical measurement*[a] | *Walking speed* | *Grip strength* | *IADL* | *Investigation period* | *No. of subjects* | *Gender (women %)* | *Age (mean ± SD)* | *Physical measurement* | *Walking speed* | *Grip strength* | *IADL* |
| A [4] | — | — | — | — | — | — | — | — | 2017.6–2018.1 | 1396 | 49.3 | 80.0 ± 4.0 | ✓ | ✓ | ✓ | — |
| B [5] | 2006.7–2008.7 | 993 | 50.8 | 73.7 ± 5.5 | ✓ | ✓ | ✓ | ✓ | — | — | — | — | — | — | — | — |
| C[6,b] | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| D [7] | 2005.6–2005.7 | 245 | 78.8 | 70.5 ± 4.5 | ✓ | ✓ | ✓ | ✓ | 2017.5–2017.10 | 190 | 83.2 | 74.6 ± 5.2 | ✓ | ✓ | ✓ | ✓ |
| E[8] | 2007.10–2007.10 | 1484 | 77.0 | 78.5 ± 4.2 | ✓ | ✓ | ✓ | ✓ | 2017.10–2017.10 | 1035 | 100.0 | 71.8 ± 4.5 | ✓ | ✓ | ✓ | ✓ |
| F [9] | 2007.5–2007.5 | 612 | 56.4 | 73.2 ± 6.2 | ✓ | ✓ | ✓ | ✓ | 2017.7–2017.7 | 707 | 60.1 | 75.1 ± 6.4 | ✓ | ✓ | ✓ | ✓ |
| G [10] | — | — | — | — | — | — | — | — | 2016.11–2016.11 | 831 | 57.2 | 72.9 ± 6.6 | ✓ | ✓ | ✓ | ✓ |
| H [11] | — | — | — | — | — | — | — | — | 2016.11–2016.12 | 1248 | 59.5 | 77.6 ± 4.8 | ✓ | ✓ | ✓ | ✓ |
| I [12] | 2008.10–2009.12 | 895 | 65.5 | 74.5 ± 6.0 | ✓ | ✓ | ✓ | — | — | — | — | — | — | — | — | — |
| J[13] | — | — | — | — | — | — | — | — | 2016. 9–2016.10 | 950 | 47.3 | 77.0 ± 5.6 | ✓ | ✓ | ✓ | ✓ |
| K [14] | 2007.4–2007.4 | 1160 | 56.7 | 74.6 ± 6.1 | ✓ | — | — | — | 2017.4–2017.4 | 874 | 56.5 | 75.8 ± 6.6 | ✓ | — | — | — |
| L [15] | — | — | — | — | — | — | — | — | 2017.6–2017.6 | 442 | 56.8 | 76.4 ± 7.2 | ✓ | ✓ | ✓ | — |
| M [16] | — | — | — | — | — | — | — | — | 2017.11–2017.12 | 379 | 74.7 | 75.5 ± 6.6 | ✓ | ✓ | ✓ | — |

✓: Items included in pooled analyses; —: ''not applicable'' or ''not available''
[a]Physical measurements include height, weight, and BMI.
[b]Cohort C was excluded in this pooled analyses because the data obtained by mail survey contained no actual measurements.
BMI, body mass index; IADL, instrumental activity of daily living; SD, standard deviation.

## Results

The characteristics of all the cohorts used in this study, including the period of study, number of subjects, gender (female %), age, dataset used in this study, and references, are summarized in Table 1. Among the cohorts that participated in the ILSA-J, six cohorts provided data of all or some of the six variables in 2007, and the number of subjects totaled 5389 (1961 men, 3428 women). The mean baseline ages of the six cohorts distributed from 70.5 ± 4.5 to 78.5 ± 4.2 years, with the youngest at 65 years and the oldest at 97 years. The pooled mean age was 74.9 years (standard error [SE] = 1.2).

Ten cohorts provided data of all six variables in 2017, from a total of 8052 subjects (3052 men and 5000 women). The mean baseline age distribution was from 71.8 ± 4.5 to 80.0 ± 4.0 years, with the youngest at 65 years and the oldest at 100 years. The pooled mean age was 75.9 years (SE = 1.3). Subjects 90 years of age and above in 2007 and 2017 were excluded from analysis, because the numbers were too small.

The degree of heterogeneity and the pooled mean values of the six study items considering heterogeneity across the cohorts in 2007 and 2017 are shown in Tables 2 and 3, and Figures 1 and 2. Cochran's $Q$ test and $I^2$ statistics showed heterogeneity for most items in most age groups and both genders, except IADL. For variables showing heterogeneity, random-effects model was used to calculate pooled means and 95% CIs.

Compared to 2007, the following changes were observed in 2017. Height increased in all age groups both in men and in women. Men showed weight gain in all age groups, while women showed weight reduction in the young-old age groups (65 to 74 years) and weight gain in the old-old age groups (75 to 89 years). BMI increased in all age groups in men, whereas in women, BMI increased only in those 85–89 years of age, but decreased in all other age groups. Increase in normal walking speed was observed in all age groups in both men and women. Grip strength also increased in old-old age groups 75 years of age and above in men and 70 years of age and above in women. Increases in IADL scores were observed in all men and women, except men in the 85–89 age group and women in the 75–79 age group.

To confirm whether rejuvenation occurred, we examined whether there were differences in secular changes of normal walking speed and handgrip strength between the 2007 and 2017 cohorts. Pseudo-microdata were constructed and analyzed with ANCOVA. The results are shown in Figure 3. The decline in normal walking speed was significantly mitigated in the 2017 cohort compared to the 2007 cohort in men 75 years of age and above and women 70 years of age and above. A similar trend of mitigation was observed for the decline in handgrip strength: considerable slowdown of decline in 2017 compared to 2007 was observed in both men and women.

## Discussion

The mean life expectancy has increased sharply during the last several decades mainly in industrialized countries.[25] In Japan, the mean life expectancy in 1946 soon after World War II was very low: 50.6 years for men and 54.0 years for women. Since then, mean life expectancy has continued to increase, reaching 81.2 for men and 87.5 for women in 2018. Even during the 10-year period of this study, mean life expectancy increased from 2007 to 2017 by 5.0 years in men and 5.1 years in women. What impact has this marked on prolongation of mean life expectancy on the physical constitution, physical function, and functional capacity of the older people in Japan? This research is an analytical study of standardized measurement data of 12 on-going long-term longitudinal cohort studies in Japan, and these studies are characterized by having relatively high accuracy. The results of this study provide some of the answers to the above question.

When examining the changes in six basic variables from 2007 to 2017, we found that men showed increases in height, weight, and BMI in 2017 compared to 2007 in all age groups. In women, however, the height increased in 2017 compared to 2007 in all age groups, but weight was reduced in the young-old age groups in 2017, while BMI decreased in all age groups, except those 85–89 years of age in 2017 compared to 2007. These results evidently show that women tend to become slimmer over a decade; even comparison was made between subjects of the same age groups. Regarding this phenomenon, the same trend can be seen in the National Health and Nutrition Survey (NHNS-J) conducted in Japan.[26] According to the survey report for the change in BMI during the 10 years from 2007 to 2017, BMI in men increased slightly from 23.90 to 24.01 in the 60's age group and 23.17 to 23.31 in the 70 and above age group. On the contrary, BMI in women decreased from 23.38 to 23.20 in the 60's age group and from 23.15 to 22.97 in the 70 and above age group. The decrease in BMI, or the tendency of slimming, in older Japanese women appears to have continued during the last decade. The main reason of the trend of BMI decrease in women might be "the desire of slimming." According to the BMI data of NHNS-J from 1947, a tendency of BMI decrease (slimming) appeared in women in the twenties in early 1960s, women in the thirties in 1970s, women in the forties in 1980s, and women in the fifties in 1990s, and this tendency of BMI decrease even began to appear in women in the sixties from 2000. From these data, BMI decrease probably appeared also in women in the seventies since 2010. The NHNS-J has reported that 20% of women 65 years of age and above had BMI of 20 kg/m$^2$, showing a tendency of undernutrition and that this situation is a noteworthy fact.

Mobility capability enables older people to live an independent life, and among the various elements of motility, walking speed is the most important and indispensable capability. Previous study has identified walking speed as a representative parameter of basic motor performance of older adults.[27] In older people, walking speed is known to be a predictive factor of overall function of daily living, risk of falling, depressive state, deteriorated ADL, admission to institution, and cognitive decline and even death.[28–32]

In this study, when we examined the change in walking speed from 2007 to 2017 in Japanese older adults living in the community, marked improvement was observed in all age groups both in men and women. The rate of change (walking speed in 2017–walking speed in 2007/walking speed in 2007) showed increases ranging from 1.6% to 6.5% in men and 5.5% to 11.6% in women, and the highest rate of increase was found in the 85–89 age group both in men and

Table 2. Pooled Means of the Six Items by Age Groups and Survey Periods (Men)

| Age group | 2007 | | | | | | | 2017 | | | | | | | Difference of 2017 and 2007[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of study | No. of subjects | Pooled means[a] | | Heterogeneity | | | No. of study | No. of subjects | Pooled means[a] | | Heterogeneity | | | |
| | | | Mean | 95% CI | Q-value | p | $I^2$ | | | Mean | 95% CI | Q-value | p | $I^2$ | |
| Height (cm) | | | | | | | | | | | | | | | |
| 65–69 | 5 | 438 | 163.91 | 162.91–164.91 | 13.02 | 0.01 | 69.27 | 7 | 404 | 165.49 | 164.41–166.56 | 18.60 | 0.00 | 67.75 | 1.58 △ |
| 70–74 | 5 | 490 | 161.98 | 160.82–163.15 | 20.67 | 0.00 | 80.65 | 8 | 663 | 164.20 | 163.42–164.99 | 19.09 | 0.01 | 63.32 | 2.22 △ |
| 75–79 | 6 | 550 | 160.29 | 159.29–161.29 | 20.43 | 0.00 | 75.53 | 9 | 985 | 162.59 | 161.87–163.30 | 26.05 | 0.00 | 69.28 | 2.30 △ |
| 80–84 | 6 | 361 | 159.16 | 157.63–160.70 | 32.74 | 0.00 | 84.73 | 9 | 639 | 161.40 | 160.44–162.36 | 31.97 | 0.00 | 74.98 | 2.24 △ |
| 85–89 | 5 | 104 | 156.81 | 154.50–159.13 | 12.23 | 0.02 | 67.30 | 9 | 276 | 158.84 | 157.24–160.44 | 39.41 | 0.00 | 79.70 | 2.03 △ |
| Weight (kg) | | | | | | | | | | | | | | | |
| 65–69 | 5 | 438 | 63.35 | 62.54–64.16 | 1.71 | 0.79 | 0.00 | 7 | 404 | 65.58 | 64.65–66.51 | 8.38 | 0.21 | 28.37 | 2.23 △ |
| 70–74 | 5 | 490 | 61.77 | 61.06–62.48 | 5.39 | 0.25 | 25.81 | 8 | 661 | 64.23 | 63.53–64.92 | 12.18 | 0.09 | 42.55 | 2.46 △ |
| 75–79 | 6 | 550 | 59.48 | 58.03–60.94 | 19.12 | 0.00 | 73.86 | 9 | 984 | 62.01 | 60.99–63.03 | 24.38 | 0.00 | 67.19 | 2.53 △ |
| 80–84 | 6 | 361 | 56.10 | 53.04–59.15 | 81.57 | 0.00 | 93.87 | 9 | 639 | 60.32 | 59.64–61.00 | 7.58 | 0.48 | 0.00 | 4.22 △ |
| 85–89 | 5 | 104 | 54.32 | 51.69–56.94 | 10.73 | 0.03 | 62.72 | 9 | 278 | 57.27 | 56.38–58.16 | 7.02 | 0.53 | 0.00 | 2.95 △ |
| BMI | | | | | | | | | | | | | | | |
| 65–69 | 5 | 438 | 23.61 | 23.35–23.88 | 4.52 | 0.34 | 11.46 | 7 | 404 | 23.81 | 23.49–24.13 | 9.68 | 0.14 | 37.99 | 0.20 △ |
| 70–74 | 5 | 490 | 23.58 | 23.04–24.13 | 20.93 | 0.00 | 80.89 | 8 | 661 | 23.85 | 23.41–24.28 | 21.01 | 0.00 | 66.68 | 0.26 △ |
| 75–79 | 6 | 550 | 23.16 | 22.42–23.89 | 38.95 | 0.00 | 87.16 | 9 | 983 | 23.41 | 23.12–23.70 | 17.37 | 0.03 | 53.94 | 0.25 △ |
| 80–84 | 6 | 361 | 22.57 | 21.99–23.16 | 18.87 | 0.00 | 73.50 | 9 | 639 | 23.07 | 22.83–23.30 | 11.33 | 0.18 | 29.41 | 0.49 △ |
| 85–89 | 5 | 104 | 21.90 | 21.37–22.43 | 8.77 | 0.07 | 54.41 | 9 | 276 | 22.66 | 22.31–23.00 | 6.09 | 0.64 | 0.00 | 0.76 △ |
| Walking speed (m/s) | | | | | | | | | | | | | | | |
| 65–69 | 4 | 300 | 1.38 | 1.23–1.52 | 102.81 | 0.00 | 97.08 | 5 | 307 | 1.40 | 1.33–1.47 | 33.49 | 0.00 | 88.06 | 0.02 △ |
| 70–74 | 4 | 340 | 1.32 | 1.19–1.46 | 103.49 | 0.00 | 97.10 | 7 | 549 | 1.35 | 1.28–1.41 | 73.43 | 0.00 | 91.83 | 0.03 △ |
| 75–79 | 5 | 425 | 1.25 | 1.13–1.37 | 103.70 | 0.00 | 96.14 | 7 | 875 | 1.31 | 1.25–1.37 | 70.67 | 0.00 | 91.51 | 0.06 △ |
| 80–84 | 5 | 270 | 1.16 | 1.05–1.28 | 43.52 | 0.00 | 90.81 | 7 | 549 | 1.23 | 1.18–1.29 | 40.53 | 0.00 | 85.20 | 0.07 △ |
| 85–89 | 4 | 80 | 1.04 | 0.87–1.21 | 28.88 | 0.00 | 89.61 | 7 | 225 | 1.10 | 1.07–1.14 | 8.62 | 0.20 | 30.42 | 0.07 △ |
| Grip strength (kg) | | | | | | | | | | | | | | | |
| 65–69 | 4 | 281 | 37.66 | 35.65–39.67 | 23.17 | 0.00 | 87.05 | 6 | 304 | 37.13 | 36.41–37.85 | 6.73 | 0.24 | 25.69 | −0.53 ▼ |
| 70–74 | 4 | 316 | 35.69 | 33.13–38.26 | 35.66 | 0.00 | 91.59 | 7 | 552 | 35.39 | 34.92–35.86 | 12.43 | 0.05 | 51.73 | −0.31 ▼ |
| 75–79 | 5 | 418 | 31.73 | 30.06–33.40 | 24.23 | 0.00 | 83.49 | 7 | 840 | 33.07 | 32.17–33.96 | 24.99 | 0.00 | 75.99 | 1.34 △ |
| 80–84 | 5 | 259 | 29.15 | 27.81–30.50 | 11.78 | 0.02 | 66.04 | 7 | 529 | 30.91 | 30.44–31.38 | 12.26 | 0.06 | 51.04 | 1.75 △ |
| 85–89 | 4 | 75 | 25.40 | 24.28–26.51 | 7.45 | 0.06 | 59.74 | 7 | 216 | 27.24 | 25.56–28.91 | 26.75 | 0.00 | 77.57 | 1.84 △ |
| IADL (score) | | | | | | | | | | | | | | | |
| 65–69 | 2 | 221 | 4.87 | 4.82–4.92 | 0.00 | 1.00 | 0.00 | 3 | 246 | 4.98 | 4.95–5.00 | 1.73 | 0.42 | 0.00 | 0.11 △ |
| 70–74 | 2 | 227 | 4.80 | 4.72–4.88 | 0.44 | 0.51 | 0.00 | 5 | 502 | 4.89 | 4.82–4.96 | 15.40 | 0.00 | 74.03 | 0.09 △ |
| 75–79 | 3 | 344 | 4.82 | 4.76–4.89 | 3.21 | 0.20 | 37.74 | 4 | 461 | 4.84 | 4.76–4.92 | 11.94 | 0.01 | 74.87 | 0.02 △ |
| 80–84 | 2 | 193 | 4.80 | 4.71–4.89 | 0.55 | 0.46 | 0.00 | 4 | 282 | 4.85 | 4.79–4.90 | 3.11 | 0.37 | 3.64 | 0.05 △ |
| 85–89 | 2 | 61 | 4.77 | 4.60–4.94 | 1.98 | 0.16 | 49.59 | 4 | 104 | 4.59 | 4.43–4.76 | 0.24 | 0.97 | 0.00 | −0.18 ▼ |

△ shows increase and ▼ shows decrease in 10 years, from 2007 to 2017.

[a]Pooled means and 95% CIs of the six items were calculated using a random-effects model if heterogeneity was present ($Q$-value: $p < 0.05$) and a fixed-effects model if heterogeneity was absent ($Q$-value: not significant).

[b]The difference values of 2017 and 2007 were calculated with subtracting 2007 from 2017.

CI, confidence interval.

Table 3. Pooled Means of the Six Items by Age Groups and Survey Periods (Women)

| | 2007 | | | | | | | 2017 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pooled means[a] | | Heterogeneity | | | | | Pooled means[a] | | Heterogeneity | | | |
| Age group | No. of study | No. of subjects | Mean | 95% CI | Q-value | p | $I^2$ | No. of study | No. of subjects | Mean | 95% CI | Q-value | p | $I^2$ | Difference of 2017 and 2007[b] |
| Height (cm) | | | | | | | | | | | | | | | |
| 65–69 | 5 | 663 | 151.60 | 150.76–152.44 | 17.53 | 0.00 | 77.19 | 8 | 926 | 153.00 | 152.28–153.72 | 25.25 | 0.00 | 72.28 | 1.40△ |
| 70–74 | 6 | 916 | 149.63 | 148.28–150.97 | 74.35 | 0.00 | 93.27 | 9 | 1225 | 151.21 | 150.52–151.89 | 37.49 | 0.00 | 78.66 | 1.58△ |
| 75–79 | 6 | 999 | 147.64 | 146.62–148.66 | 34.54 | 0.00 | 85.52 | 10 | 1585 | 149.71 | 149.15–150.28 | 39.16 | 0.00 | 77.01 | 2.07△ |
| 80–84 | 6 | 643 | 145.06 | 143.38–146.73 | 53.06 | 0.00 | 90.58 | 10 | 883 | 148.06 | 146.89–149.24 | 90.05 | 0.00 | 90.01 | 3.00△ |
| 85–89 | 6 | 191 | 144.05 | 141.31–146.79 | 56.73 | 0.00 | 91.19 | 9 | 287 | 145.41 | 144.79–146.04 | 10.27 | 0.25 | 22.08 | 1.37△ |
| Weight (kg) | | | | | | | | | | | | | | | |
| 65–69 | 5 | 663 | 53.60 | 52.99–54.20 | 5.39 | 0.25 | 25.73 | 8 | 924 | 53.15 | 52.59–53.70 | 12.95 | 0.07 | 45.95 | –0.45▼ |
| 70–74 | 6 | 916 | 52.50 | 51.29–53.71 | 24.92 | 0.00 | 79.93 | 9 | 1222 | 51.74 | 51.31–52.18 | 9.50 | 0.30 | 15.77 | –0.76▼ |
| 75–79 | 6 | 999 | 50.46 | 49.37–51.56 | 18.83 | 0.00 | 73.44 | 10 | 1583 | 50.82 | 50.43–51.21 | 14.44 | 0.11 | 37.68 | 0.35△ |
| 80–84 | 6 | 643 | 48.79 | 47.39–50.19 | 20.20 | 0.00 | 75.25 | 10 | 884 | 49.96 | 49.16–50.77 | 19.13 | 0.02 | 52.95 | 1.17△ |
| 85–89 | 6 | 191 | 45.56 | 43.90–47.22 | 12.13 | 0.03 | 58.77 | 9 | 289 | 47.44 | 46.55–48.33 | 5.70 | 0.68 | 0.00 | 1.88△ |
| BMI | | | | | | | | | | | | | | | |
| 65–69 | 5 | 663 | 23.27 | 22.76–23.78 | 17.84 | 0.00 | 77.58 | 8 | 923 | 22.64 | 22.42–22.87 | 9.13 | 0.24 | 23.35 | –0.63▼ |
| 70–74 | 6 | 916 | 23.43 | 22.61–24.25 | 71.26 | 0.00 | 92.98 | 9 | 1217 | 22.64 | 22.34–22.94 | 19.96 | 0.01 | 59.93 | –0.79▼ |
| 75–79 | 6 | 999 | 23.15 | 22.44–23.87 | 45.51 | 0.00 | 89.01 | 10 | 1578 | 22.69 | 22.38–23.00 | 28.41 | 0.00 | 68.32 | –0.46▼ |
| 80–84 | 6 | 643 | 23.32 | 22.25–24.40 | 70.04 | 0.00 | 92.86 | 10 | 881 | 22.84 | 22.40–23.28 | 30.61 | 0.00 | 70.60 | –0.49▼ |
| 85–89 | 6 | 191 | 21.96 | 20.54–23.39 | 42.85 | 0.00 | 88.33 | 9 | 287 | 22.52 | 22.14–22.89 | 11.95 | 0.15 | 33.03 | 0.56△ |
| Walking speed (m/s) | | | | | | | | | | | | | | | |
| 65–69 | 4 | 487 | 1.36 | 1.27–1.46 | 85.38 | 0.00 | 96.49 | 7 | 781 | 1.44 | 1.40–1.47 | 22.33 | 0.00 | 73.13 | 0.07△ |
| 70–74 | 5 | 712 | 1.30 | 1.19–1.42 | 203.99 | 0.00 | 98.04 | 8 | 1055 | 1.40 | 1.37–1.43 | 34.41 | 0.00 | 79.66 | 0.10△ |
| 75–79 | 5 | 832 | 1.21 | 1.10–1.32 | 165.65 | 0.00 | 97.59 | 9 | 1394 | 1.32 | 1.30–1.35 | 29.70 | 0.00 | 73.06 | 0.11△ |
| 80–84 | 5 | 512 | 1.09 | 0.97–1.20 | 79.84 | 0.00 | 94.99 | 9 | 742 | 1.21 | 1.17–1.25 | 36.62 | 0.00 | 78.15 | 0.12△ |
| 85–89 | 5 | 140 | 0.96 | 0.80–1.11 | 70.83 | 0.00 | 94.35 | 7 | 231 | 1.07 | 1.03–1.10 | 12.43 | 0.05 | 51.74 | 0.11△ |
| Grip strength (kg) | | | | | | | | | | | | | | | |
| 65–69 | 4 | 490 | 23.56 | 21.52–25.60 | 94.94 | 0.00 | 96.84 | 7 | 796 | 23.44 | 22.69–24.19 | 36.17 | 0.00 | 83.41 | –0.12▼ |
| 70–74 | 5 | 699 | 21.51 | 20.10–22.93 | 69.27 | 0.00 | 94.23 | 8 | 1062 | 22.69 | 21.73–23.66 | 95.32 | 0.00 | 92.66 | 1.18△ |
| 75–79 | 5 | 793 | 20.36 | 19.22–21.49 | 55.00 | 0.00 | 92.73 | 9 | 1363 | 21.23 | 20.56–21.90 | 68.45 | 0.00 | 88.31 | 0.87△ |
| 80–84 | 5 | 495 | 18.41 | 16.81–20.01 | 55.54 | 0.00 | 92.80 | 9 | 727 | 19.94 | 19.28–20.60 | 40.78 | 0.00 | 80.38 | 1.53△ |
| 85–89 | 5 | 129 | 15.58 | 14.95–16.21 | 2.69 | 0.61 | 0.00 | 8 | 225 | 18.62 | 17.48–19.76 | 50.01 | 0.00 | 86.00 | 3.04△ |
| IADL (score) | | | | | | | | | | | | | | | |
| 65–69 | 2 | 235 | 4.93 | 4.88–4.98 | 0.14 | 0.71 | 0.00 | 4 | 686 | 4.95 | 4.93–4.98 | 0.61 | 0.89 | 0.00 | 0.02△ |
| 70–74 | 3 | 488 | 4.95 | 4.89–5.00 | 7.14 | 0.03 | 72.00 | 4 | 830 | 4.98 | 4.97–4.99 | 5.64 | 0.13 | 46.77 | 0.04△ |
| 75–79 | 4 | 707 | 4.96 | 4.95–4.98 | 1.59 | 0.66 | 0.00 | 4 | 808 | 4.96 | 4.95–4.98 | 2.22 | 0.53 | 0.00 | 0.00— |
| 80–84 | 3 | 432 | 4.83 | 4.77–4.89 | 5.55 | 0.06 | 63.97 | 5 | 411 | 4.95 | 4.92–4.98 | 8.63 | 0.07 | 53.64 | 0.12△ |
| 85–89 | 3 | 114 | 4.63 | 4.45–4.80 | 0.72 | 0.70 | 0.00 | 4 | 124 | 4.87 | 4.79–4.96 | 3.71 | 0.29 | 19.23 | 0.24△ |

△ shows increase and ▼ shows decrease in 10 years, from 2007 to 2017.
[a]Pooled means and 95% CIs of the six items were calculated using a random-effects model if heterogeneity was present (*Q*-value: $p < 0.05$) and a fixed-effects model if heterogeneity was absent (*Q*-value: not significant).
[b]The difference values of 2017 and 2007 were calculated with subtracting 2007 from 2017.

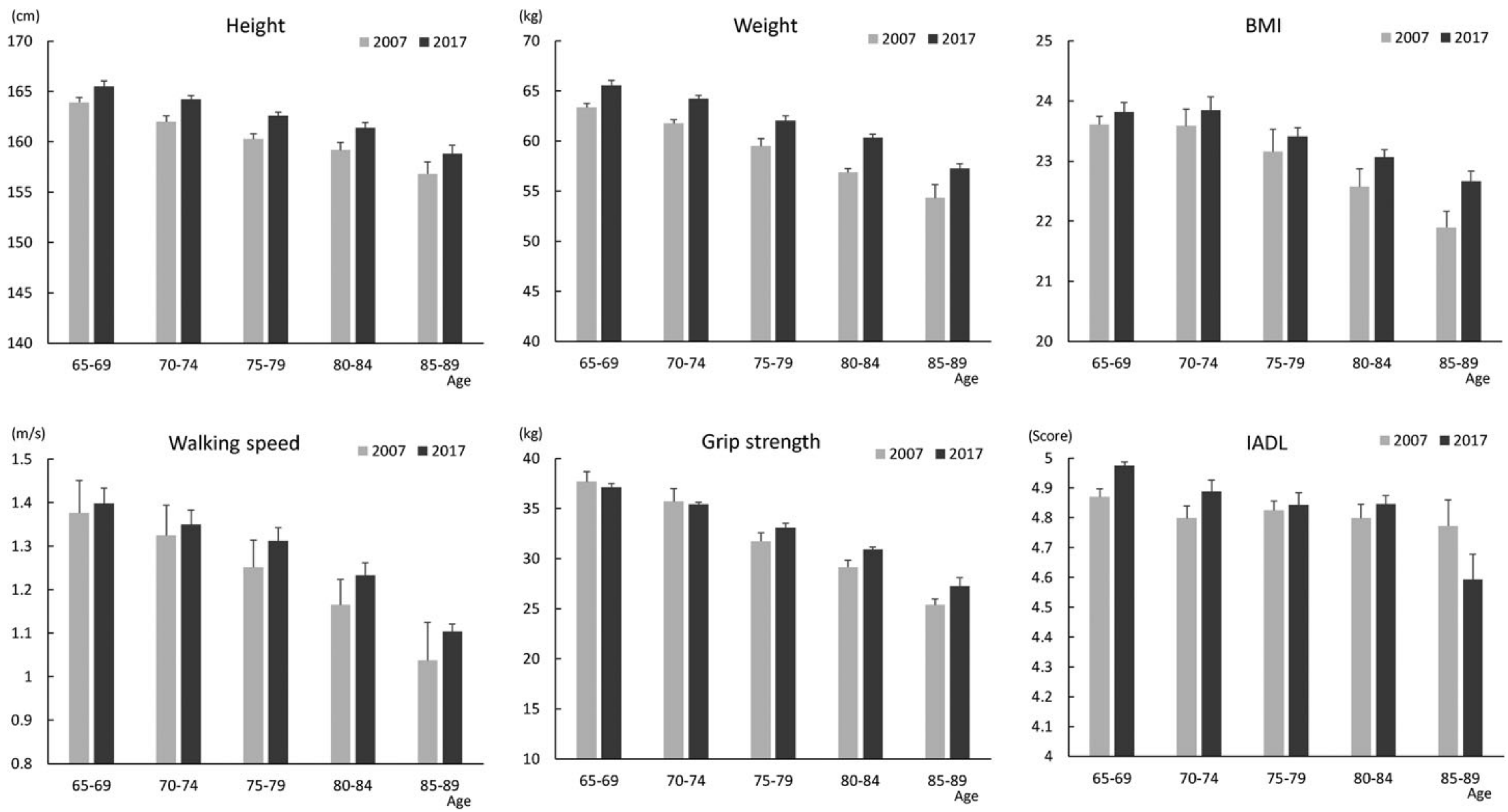


**FIG. 1.** Pooled mean and SE of six items by age groups and survey period (men). Pooled mean and SE were calculated using a random-effects model if heterogeneity was present (*Q*-value: $p < 0.05$) and a fixed-effects model if heterogeneity was absent (*Q*-value: not significant). SE, standard error.

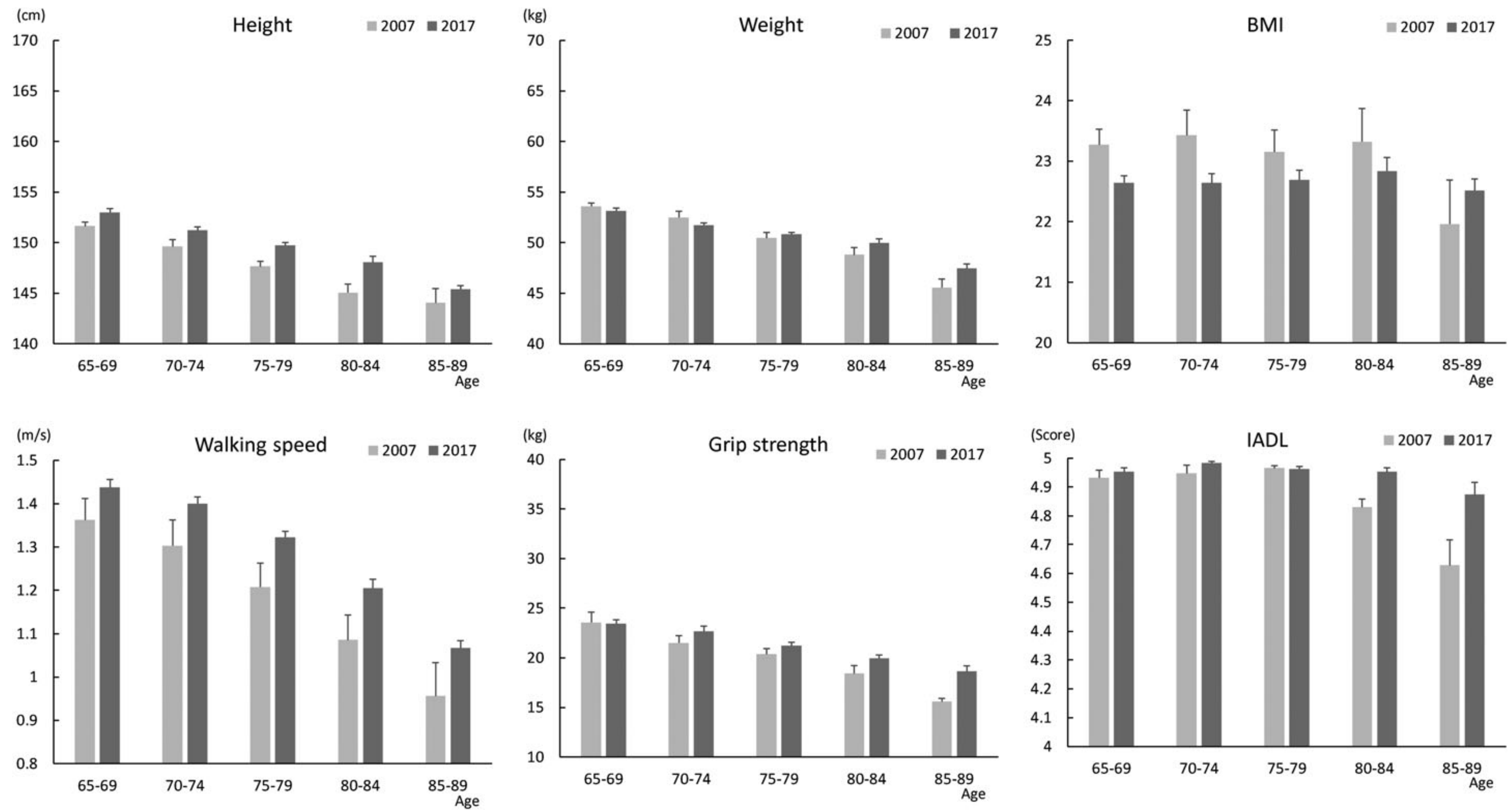


**FIG. 2.** Pooled mean and SE of six items by age groups and survey periods (women). Pooled means and SE were calculated using a random-effects model if heterogeneity was present ($Q$-value: $p < 0.05$) and a fixed-effects model if heterogeneity was absent ($Q$-value: not significant).

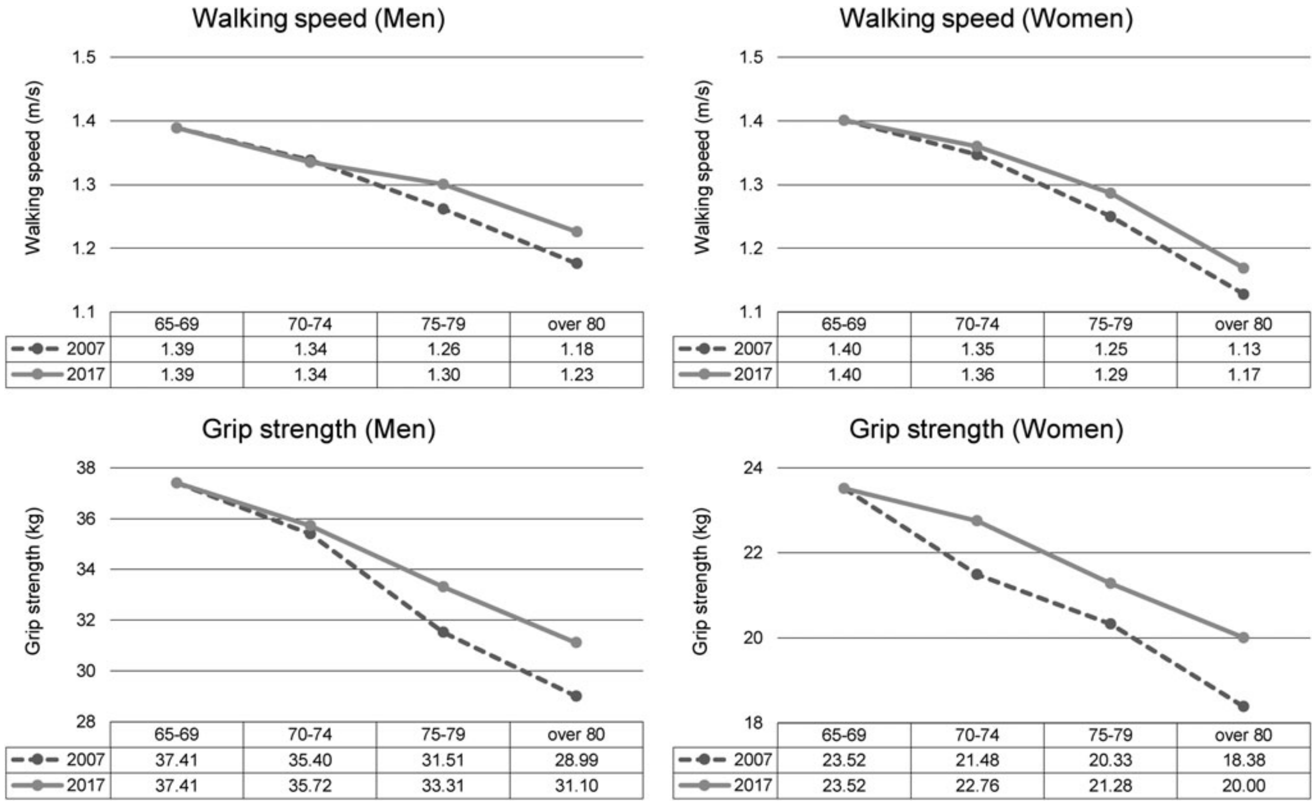


**FIG. 3.** Differences between the secular changes in 2007 and 2017 cohorts. (The results of ANCOVA with the baseline valuables of each cohort as covariance). ANCOVA, analysis of covariance.

women. Especially in women, the increase rates exceeded 10% in all the old-old age groups, and this degree of improvement in walking speed was indeed striking. Furthermore, comparison of decline in walking speed stratified by 5-year age group in the 2007 and 2017 cohorts showed significantly slower decline in the 75–79 and 80–84 groups for men as well as in the 70–74, 75–79, and 80–84 groups for women in the 2017 cohort as shown in Figure 3. In addition to the faster walking speed, mitigation of decline in walking speed is probably a continuous phenomenon that has occurred even before 2007.

The first author previously reported the changes in physical functions, including walking speed in Japanese older people from 1992 to 2002, based on the data obtained from TMIG-LISA.[1] In 1992, the normal walking speed of all subjects 65 years of age and above was $1.16 \pm 0.27$ m/s in men and $1.00 \pm 0.27$ m/s in women. In 2002, the age group with the same walking speed as above was the 76 years and above group both in men and women ($1.17 \pm 0.30$ in men and $1.00 \pm 0.27$ in women). In other words, with respect to normal walking speed, both men and women were rejuvenated by 11 years from 1992 to 2002.[1,2]

We then attempted to synthesize the 1992 to 2002 data of the TMIG-LISA with the data obtained in this study with regard normal walking speed. For example, for men 65–69 years of age, the walking speeds were 1.26 m/s in 1992, 1.36 m/s in 2002, 1.38 m/s in 2007, and 1.40 m/s in 2017, while for those 80–84 years of age, the walking speeds were 0.86, 1.07, 1.15 and 1.23, respectively. For women 65–69 years of age, the walking speeds (m/s) were 1.16 in 1992, 1.33 in 2002, 1.36 in 2007, and 1.44 in 2017, while for those 80–84 years of age, they were 0.79, 0.95, 1.09, and 1.21 (m/s), respectively. In both older men and women of all age groups, the normal walking speed became faster in ascending order of 1992, 2002, 2007, and 2017. In other words, Japanese older adults living in the community have consistently shown increase in walking speed over the last 25 years, and the improvement in walking speed is especially striking in women.

In the analysis of the change in grip strength over the last 10 years, the mean grip strengths in 2017 were higher compared with that in 2007 in all age groups both in men and women, except the 65–69 age group in both sexes and 70–74 age group in men. These findings thus indicate that grip strength increases markedly in both men and women over the last decade, at least in the old-old population. Also, comparison of decline in grip strength stratified by 5-year age group in the 2007 and 2017 cohorts showed much less decline in both men and women in the 2017cohort. The skeletal muscle mass and muscle strength are extremely important to support functioning during old age. In general, decrease in skeletal muscle mass accelerates after 30 years of age.[33] Decrease in skeletal muscle mass due to aging is recognized as an important factor for the decline of muscle strength. Grip strength as well as walking speed are key components of physical performance in older people[34] and good predictors of functional capacity decline and even all-cause mortality.[35] Sarcopenia, which is defined as loss of muscle mass and function, has recently become an important issue in the aging society because sarcopenia can lead to critical reduction in functional capacity and cause disability.[36] Since hand grip strength shows high correlation with muscle strength in many parts of the body, this parameter has strong association with sarcopenia, which progresses with aging. With the additional advantages of being easy and safe to measure, grip strength is indispensable for the evaluation of sarcopenia.[37]

IADL is one of the crucial indicators of daily life functioning and survival of older people. For the IADL-related subscale of TMIG-IC, except men 85–89 years of age and women 75–79 years of age, both men and women of all other age groups achieved higher mean scores in 2017 compared to 2007. Especially in the young-old population, men and women scored 4.89 or higher out of 5 (98%) in 2017, showing almost score saturation for the IADL-related subscale. When analyzed by gender, all women, except those 85–89 years of age scored 4.95 (99%) or higher, which was higher than the score for men, clearly demonstrating that women exhibit high ADL capability. In a recent report of a cohort study of community-dwelling older Japanese, which assessed higher level functional capacity using the IADL subscale of TMIG-IC, a decreasing aging trajectory in higher level functional capacity was associated with higher risk of death and higher monthly long-term care costs.[38]

This study revealed that compared to the older cohort in 2007, the recent cohort in 2017 showed significantly higher performance in walking speed, grip strength, and IADL, which are closely associated with functional capacity, and the recent cohort also exhibited slowed decline in walking speed and grip strength compared to the older cohort. These findings indicate that at population level, the functional decline is mitigated in the recent cohort compared to that of a decade ago.

As discussed above, from the analysis of the changes in six functioning-related variables over the past decade, the findings suggest that in the super-aged Japanese society as a result of prolonged life expectancy, the older people making up this society attain a higher level of health status and functioning compared to a decade ago. Prolonged life expectancy and increase in older population have not resulted in just an increase of frail older population (as in the old days), but a net increase of highly active older people full of vitality, who possess high physical functions. There are many reasons why today's Japanese older people are so healthy and active. First, nutritional status has improved through increases in animal protein to total protein ratio and dietary variety.[39,40] Second, lifestyle-related diseases in midlife to old age, such as stroke, heart diseases, and obesity, have been relatively well controlled and prevented.[41,42] Third, increase in social participation among community-dwelling older people may have reduced the risk of incident functional disability and depressive symptoms.[43,44] Oshio[45] examined the health-related capacity of older Japanese to work and the trend between 1986 and 2016 using data from nationwide and population-based surveys. They found clear trends of improvement in all health variables in both men and women 65 to 69 years of age and 70 to 74 years of age. Considering these studies, it can be said that the health status of older Japanese, particularly those so-called ''young-old people,'' has been definitely improved and rejuvenation seems to have continued for the last two or three decades.

This study has several limitations. The first limitation is the use of representative samples. This study consisted of 12 relatively high-quality cohort studies in Japan, from which we collected the mean ± standard deviation of measurements for each cohort and performed pooled analysis on the data. Each cohort study was not an exhaustive survey, including all individuals of the study population (whole population survey), and the cohort consisted of a sample of individuals with relatively high health level, who responded to invitations to participate in health checks. Our previous studies showed that the participants and nonparticipants of these health checks for older people differed not only in health level but also in mortality during a 3-year follow-up period.[46,47] However, in this study, we made efforts to select studies with samples representative of the populations. In addition, as discussed above regarding BMI, there were no great differences between our findings and the data obtained from nationwide surveys such as the NHNS-J. Therefore, we consider that this research represents the general health status of the community-dwelling older population in Japan.

The second limitation is related to the dataset analyzed in this study. Because pooled analysis was performed using only group data of surveys (number of subjects or mean and standard deviation of each variable) and not the individual data of surveyed subjects, we were not able to consider dropout rate or shift of distribution (proportion of those improved or deteriorated) of each variable in our analyses. We were also not able to adjust for individual health status such as frailty and socioeconomic factors that affect the secular changes of functional capacity during follow-up periods when comparing the 2007 and 2017 cohorts.

The third limitation is the heterogeneity across cohorts. In this study, although all cohort studies used relatively standardized methods to measure health-related parameters, there was a significant degree of heterogeneity across studies as assessed by Cochran's $Q$ test and $I^2$ statistics in most analyses. However, heterogeneity is often inevitable in pooled analyses of observational studies, and it does not necessarily invalidate the findings.[48,49] The presence of heterogeneity also suggests that it might be difficult to conclude the phenomenon with one study. Although it is necessary to obtain more information about the study protocol and verify the cause of heterogeneity in the future, this study is meaningful for attempting to find the Japanese population mean with minimal bias using meta-analysis considering heterogeneity.

Notwithstanding the above limitations, it is both relevant and important to analyze and report the long-term changes of major health-related measures in the older population in Japan, a country that ranks among the top countries in average life expectancy and already experiencing a super-aged society. Especially, the finding of marked improvement in normal walking speed, an indicator of functioning in the older people, over a period of 25 years may represent a phenomenon of ''rejuvenation'' in the older people. This result implies that the increase in aged population accompanying prolonged mean life expectancy in this era does not increase frail older people as was observed in the past, but rather increases independent older people with good health and vitality.[2] Hence, the importance of the older population as a social resource in the aged society should be reacknowledged.

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No competing financial interests exist for all authors.

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