ORIGINAL

Changes in higher-level functional capacity during the COVID-19 pandemic among older adults living in Japan

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Abstract : Objective : To evaluate change in higher-level functional capacity of older Japanese individuals during the COVID-19 pandemic. Methods : Four hundred older Japanese individuals completed an online questionnaire in early May 2021. Participants were asked retrospectively about their higher-level functional capacity and lifestyle before and during the COVID-19 pandemic. Higher-level functional capacity was determined as total score on the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC). Total TMIG-IC score ranges from 0 to 13. A decline in higher-level functional capacity was defined as a decrease in TMIG-IC score of more than 2 points during the COVID-19 pandemic. Changes in higher-level functional capacity during the COVID-19 pandemic were assessed by paired t-test and a general linear model. Results : Decreased TMIG-IC scores were found in 43 (21.5%) men and 61 (30.5%) women. Among those with higher-level functional capacity, scores for total TMIG-IC and Social Role decreased significantly in both sexes (all $p < 0.005$). Conclusion : The findings suggest an association of the COVID-19 pandemic with a decrease in higher-level functional capacity, especially in Social Role, among older adults living in Japan. J. Med. Invest. 71 : 66-74, February, 2024

Keywords **:** *COVID-19, higher-level functional capacity, older Japanese community dwellers*

INTRODUCTION

Activities of daily living (ADL) are the skills that enable people to manage their own physical needs (1). The basic ADL (BADL) include bathing, transferring, dressing, eating, and using the toilet and are essential to enable older people to live independently. A decline in BADL reduces people's ability to live independently and makes it necessary for them to rely on help from others (1). However, simple maintenance of BADL does not necessarily mean that older people are able to live independently in the community ; it is important to maintain a higher functional capability than BADL (2). Such functional capability includes cooking, shopping, money management, use of public transportation, and other activities that reflect an ability to live independently in the community (3). Based on Lawton's model, the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) was developed to evaluate higher functional capability. The last three subscales of Lawton's model, i.e., Instrumental Self-Maintenance, Intellectual Activity, and Social Role (4), are helpful for detecting disability among community-dwelling older people (2, 5). A previous study that used the TMIG-IC (6) reported that a decline in ADL stems from a decline in higher functional capabilities such as Social Role, eventually resulting in a decline in BADL. Therefore, it is important to prevent a decline in higher functional capabilities, including Social Role, Intellectual Activity, and Instrumental Self-Maintenance.

COVID-19 spread worldwide and the World Health Organization issued a pandemic declaration in March 2020 (7). The pandemic affected the global economy by damaging economic systems involving trade complementarity, capital, materialism, and cash flow (8-10), in addition to causing the deaths of many infected people (11). Japan had one of the earliest exposures to COVID-19 due to a cruise ship incident (11) and the policy dilemma surrounding the Olympic Games. Lockdowns were implemented in many countries, including the United States, France, and Spain, to prevent the rapid spread of COVID-19, and the first national emergency declaration was issued in Japan from April to May 2020 (12). During the state of emergency in Japan, it was possible to leave the home when necessary, but there were major changes in daily life resulting from measures such as the implementation of work-from-home and the encouragement of refraining from unnecessary outings. Due to these domestic COVID-19 infection control measures, Japan had the fewest clinical manifestations and the lowest mortality rate when compared with other countries in north-east Asia and the Pacific (e.g., Taiwan, South Korea, Vietnam, New Zealand, Australia, Papua New Guinea, and Fiji) (11) From the early days of the COVID-19 pandemic, it was reported that older people were more likely to become ill, and they faced severe restrictions on their activities in their daily lives.

It is thus possible that the preventive measures associated with the spread of COVID-19 could have significantly changed people's lives and higher-level functional capacity. Several studies have reported a relationship between quarantine during the COVID-19 pandemic and worse physical function in terms of ADL and instrumental activities of daily living (IADL) in older adults (13, 14). A study that investigated changes in lifestyle conditions among older Central American adults during the

Abbreviations :
ADL, activities of daily living ; BADL, basic activities of daily living ; IADL, instrumental activities of daily living ; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence ; SD, standard deviation

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pandemic confirmed the impact of quarantine on ADL (13) and another reported a decrease in both ADL and IADL during the pandemic in older American adults (14). However, no study has evaluated changes in higher-level functional capacity during the pandemic among older Japanese people living independently in the community. Thus, the aim of this study was to clarify changes in higher-level functional capacity during the COVID-19 pandemic in Japan in community-dwelling older adults living independently, who are at highest risk of becoming severely ill from COVID-19.

MATERIALS AND METHODS

Study design and participants

We conducted a cross-sectional Internet panel survey of participants who were already registered with an Internet survey company (ASMARQ Co., Ltd., Tokyo, Japan). This cross-sectional survey was conducted throughout Japan between 13 May 2021 and 14 May 2021 with Internet users aged 60 years or older who registered for the survey in advance. In this study, we used an Internet panel survey and focused on the effect of the COVID-19 pandemic on decline in TMIG-IC score among community-dwelling older adults who were living independently. Therefore, considering that a decline in higher-level functional capacity might begin prior to the age of 65 years (15), we defined eligible older participants as those aged over 60 years who had been residing in Japan during the survey term and had free access to a computer or tablet with an Internet connection. The questionnaire was designed to collect information regarding the period both before and during the COVID-19 pandemic, and the questionnaire items were displayed on the ASMARQ website. Participants completed the questionnaire by marking a response column, and the responses were submitted automatically.

A total of 400 people who had registered with the survey company completed the survey and were included in the present study. The participants were extracted on the basis of the population composition ratios for residential areas (Supplemental table 1) to ensure a male/female ratio of 1 : 1. All of those registered with the survey company had been registered by open recruitment. In January 2019, the total number of monitors was about 900,000. As a countermeasure against incorrect answers, a system check was performed by ASMARQ at the time of registration to prevent duplicate registration and identify invalid responses (such as those produced by bots) by using registration information, in addition to a mandatory update of monitor registration information once a year.

The study protocol was approved by the institutional review board of Tokushima University Hospital (approval No. 3963). Personal information and privacy protection are covered by the policies of both the registered monitor and research company, and participants' information was thus considered to be adequately protected. All participants were informed that the purpose of the study was to investigate health consciousness and lifestyle including food choices during the lockdown, and indicated their consent for participation in the survey by clicking on a button confirming their agreement to do so.

Assessment of higher-level functional capacity

Higher-level functional capacity was assessed using the TMIG-IC, which is a widely used scale for evaluation of activities of daily living and is based on Lawton's hierarchical model of behavioral competence among older people (2). It is a multi-dimensional evaluation method consisting of 13 items in the following three subscales : Instrumental Self Maintenance (five items), Intellectual Activity (four items), and Social Role (four items). The response to each item is scored either 'yes' (able to do) for 1 point or 'no' (unable to do) for 0 points, with possible scores ranging from 0 to 13 points. A higher score reflects higher functional capability. Decline in total TMIG-IC score, Instrumental Self-Maintenance, Intellectual Activity, and Social Role during the COVID-19 pandemic was defined as a > 2-point, 1-point, 2-point, and 2-point decrease in score, respectively.

Other measurements

Data regarding sex, age, body weight, living area, living alone, self-rated health, level of education, annual household income, drinking habit, and smoking habit were collected using online open-ended questions.

Lifestyle was assessed by simple online open-ended questions about television viewing (hours / day), sleep (hours / day), frequency of physical activity (times / week), frequency of going out (times / week), and frequency of conversation with others (times / week).

Statistical analysis

Continuous variables are expressed as means ± standard deviation (SD), and categorical variables are expressed as numbers and proportions (%).

We used the paired t-test to assess differences in higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by sex or age group (< 65 years / ≥ 65 years). To assess differences in higher-level functional capacity associated with the COVID-19 pandemic, we used a generalized linear model by sex or age group after controlling for the following variables. When we used a generalized linear model for higher-level functional capacity and lifestyle factors except for physical activity by sex, the confounding variables were 1) age-adjusted model, age (continuous, years) ; 2) multivariable-adjusted model, age-adjusted model + living area (categorical ; Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku/Shikoku, or Kyushu), living status (binary ; living alone or cohabitation), level of education (categorical ; ≤ 9 years, 9–12 years, or > 12 years), annual household income (categorical ; ≤ 1.49 million yen, 1.5–5.49 million yen, ≥ 5.5 million yen, or unknown), smoking habit (categorical ; current, former, or never), drinking habit (categorical ; current, former, or never), physical activity (continuous, times / week) and body weight (continuous, kg). When a generalized linear model was used for physical activity alone, adjustments were performed for age, area, living status, education level, annual household income, smoking habit, drinking habit, and body weight. When we used a generalized linear model for higher-level functional capacity and lifestyle factors except for physical activity by age group, the confounding variables were 1) sex-adjusted model, sex (binary, male or female) ; 2) multivariable-adjusted model, sex-adjusted model + living area, living status, level of education, annual household income, smoking habit, drinking habit, physical activity, and body weight. When a generalized linear model was used for physical activity alone, adjustments were performed for sex, area, living status, education level, annual household income, smoking habit, drinking habit, and body weight.

All statistical tests were based on two-sided probabilities and were performed using SPSS version 25.0J for Windows (IBM Inc., Japan, Tokyo Japan). All p values < 0.05 were considered statistically significant.

RESULTS

Participant characteristics

Table 1 shows the characteristics of the participants by sex.

Mean age was 67.0 ± 5.3 years in men and 66.6 ± 5.0 years in women. The proportion of highly educated participants (> 12 years of education) was 73.0% in men and 63.5% in women. The proportion of participants with self-rated health of normal or better was 89.0% in men and 91.5% in women. Because the participants were extracted on the basis of the population composition ratios for residential areas to achieve a male/female ratio of 1 : 1 (Supplemental table 1), ratios of the present participants by living area were similar to the population composition ratios for residential areas in Japan.

Change in higher-level functional capacity and lifestyle factors by sex

Table 2 shows change in higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by sex. Total TMIG-IC score (−0.61 ± 1.26, $p < 0.001$ in men ; −0.88 ± 1.33, $p < 0.001$ in women) decreased significantly during the pandemic, in both sexes. In the three subscales of higher-level functional capacity, scores for Instrumental Self-Maintenance (−0.05 ± 0.29, $p = 0.029$ in men ; −0.06 ± 0.27, $p = 0.004$ in women) and Social Role (−0.57 ± 1.10, $p < 0.001$ in men ; −0.83 ± 1.16, $p < 0.001$ in women) decreased significantly in both sexes.

Time spent viewing television (0.36 ± 1.31 [hours / day], $p < 0.001$ in men ; 0.58 ± 1.19 [hours / day], $p < 0.001$ in women) increased significantly during the pandemic in both sexes. Frequency of going out (−0.52 ± 3.32 [times / week], $p = 0.030$ in men ; −0.92 ± 2.54 [times / week], $p < 0.001$ in women) and conversation with others (−0.37 ± 0.90 [times / week], $p < 0.001$ in men ; −0.85 ± 1.91 [times / week], $p < 0.001$ in women) decreased

Table 1. Characteristics of participants by sex

	Men (n = 200)	Women (n = 200)	*p*-value
Age (years)	67.0 ± 5.3	66.6 ± 5.0	0.387
Body weight (kg)	67.2 ± 11.3	53.5 ± 12.8	< 0.001
Education			
≤ 9 years	2 (1.0)	2 (1.0)	< 0.001
9–12 years	52 (26.0)	71 (35.5)	
> 12 years	146 (73.0)	127 (63.5)	
Annual household income			
≤ 1.49 million yen	16 (8.0)	16 (8.0)	0.716
1.50–5.49 million yen	81 (40.5)	84 (42.0)	
≥ 5.50 million yen	81 (40.5)	72 (36.0)	
Unknown	22 (11.0)	28 (14.0)	
Area of residence			
Hokkaido	11 (5.5)	9 (4.5)	0.199
Tohoku	5 (2.5)	12 (6.0)	
Kanto	100 (50.0)	99 (49.5)	
Chubu	18 (9.0)	16 (8.0)	
Kansai	36 (18.0)	45 (22.5)	
Chugoku / Shikoku	15 (7.5)	12 (6.0)	
Kyushu	15 (7.5)	7 (3.5)	
Living alone	30 (15.0)	34 (17.0)	0.341
Smoking habit			
Current	66 (33.0)	16 (8.0)	< 0.001
Former	86 (43.0)	33 (16.5)	
Never	48 (24.0)	151 (75.5)	
Drinking habit			
Current	159 (79.5)	97 (48.5)	< 0.001
Former	19 (9.5)	15 (7.5)	
Never	22 (11.0)	88 (44.0)	
Self-rated health			
Very good	10 (5.0)	11 (5.5)	0.824
Good	55 (27.5)	64 (32.0)	
Normal	113 (56.5)	108 (54.0)	
Poor	21 (10.5)	16 (8.0)	
Very poor	1 (0.5)	1 (0.5)	

Data are presented as the mean ± SD or as the number (%).

Table 2. Comparison of higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by sex

	Before lockdown	During lockdown	Difference during vs. before	*p*-value ‡	Increased during vs. before §	Unchanged during vs. before ¶	Decreased during vs. before ††	Decline in higher-level functional capacity ‡‡
	mean (SD)	mean (SD)	mean (SD)		n (%)	n (%)	n (%)	n (%)
Men, n = 200								
Total TMIG-IC score (score) †	10.93 (2.05)	10.33 (2.10)	–0.61 (1.26)	<0.001	10 (5.0)	123 (61.5)	67 (33.5)	43 (21.5)
Instrumental Self-Maintenance (score) †	4.90 (0.46)	4.85 (0.43)	–0.05 (0.29)	0.029	2 (1.0)	186 (93.0)	12 (6.0)	12 (6.0)
Intellectual Activity (score) †	3.28 (0.96)	3.28 (0.97)	0.01 (0.31)	0.819	10 (5.0)	181 (90.5)	9 (4.5)	0 (0.0)
Social Role (score) †	2.76 (1.32)	2.20 (1.40)	–0.57 (1.10)	<0.001	8 (4.0)	130 (65.0)	62 (31.0)	39 (19.5)
Television viewing (hours / day)	3.7 (2.37)	4.06 (2.65)	0.36 (1.31)	<0.001	45 (22.5)	150 (75.0)	5 (2.5)	–
Sleep (hours / day)	6.65 (0.96)	6.67 (1.03)	0.02 (0.39)	0.467	16 (8.0)	173 (86.5)	11 (5.5)	–
Physical activity (times / week)	2.64 (2.69)	2.66 (2.88)	0.03 (1.51)	0.815	25 (12.5)	152 (76.0)	23 (11.5)	–
Going out (times / week)	5.04 (5.81)	4.53 (5.78)	–0.52 (3.32)	0.030	13 (6.5)	126 (63.0)	61 (30.5)	–
Conversation with others (times / week)	1.00 (1.49)	0.63 (1.18)	–0.37 (0.9)	<0.001	6 (3.0)	142 (71.0)	52 (26.0)	–
Women, n = 200								
Total TMIG-IC score (score) †	11.91 (1.56)	11.03 (1.88)	–0.88 (1.33)	<0.001	6 (3.0)	107 (53.5)	87 (43.5)	61 (30.5)
Instrumental Self-Maintenance (score) †	4.98 (0.17)	4.93 (0.30)	–0.06 (0.27)	0.004	11 (5.5)	188 (94.0)	1 (0.5)	11 (5.5)
Intellectual Activity (score) †	3.55 (0.80)	3.55 (0.78)	0.01 (0.31)	0.819	7 (3.5)	187 (93.5)	6 (3.0)	1 (0.5)
Social Role (score) †	3.39 (0.99)	2.56 (1.36)	–0.83 (1.16)	<0.001	3 (1.5)	111 (55.5)	86 (43.0)	57 (28.5)
Television viewing (hours / day)	4.03 (2.65)	4.61 (2.98)	0.58 (1.19)	<0.001	74 (37)	117 (58.5)	9 (4.5)	–
Sleep (hours / day)	6.58 (0.98)	6.63 (1.07)	0.05 (0.47)	0.180	21 (10.5)	169 (84.5)	10 (5.0)	–
Physical activity (times / week)	2.62 (2.68)	2.39 (2.69)	–0.23 (1.44)	0.028	14 (7.0)	146 (73.0)	40 (20.0)	–
Going out (times / week)	4.76 (3.25)	3.84 (2.62)	–0.92 (2.54)	<0.001	13 (6.5)	104 (52.0)	83 (41.5)	–
Chatting (times / week)	1.79 (2.40)	0.95 (1.54)	–0.85 (1.91)	<0.001	9 (4.5)	106 (53.0)	85 (42.5)	–

† Score ranges of total TMIG-IC score, Instrumental Self-Maintenance, Intellectual Activity, and Social Role were 0–13, 0–5, 0–4, and 0–4, respectively.
‡ Paired *t*-test.
§ Corresponds to participants with Δ higher-level functional capacity > 0.
¶ Corresponds to participants with Δ higher-level functional capacity = 0.
†† Corresponds to participants with Δ higher-level functional capacity < 0.
‡‡ Decline in total TMIG-IC score, Instrumental Self-Maintenance, Intellectual Activity, and Social Role during the COVID-19 pandemic was defined as a > 2-point, 1-point, 2-point, and 2-point decrease in score, respectively.

significantly in both sexes. In women, frequency of physical activity (–0.23 ± 1.44 [times / week], $p = 0.028$) decreased significantly.

Change in higher-level functional capacity and lifestyle factors by age group

Table 3 shows change in higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by age group. Total TMIG-IC score (–0.77 ± 1.29, $p < 0.001$ in participants aged < 65 years ; –0.73 ± 1.31, $p < 0.001$ in participants aged ≥ 65 years) decreased significantly during the pandemic in both age groups. In the three subscales of higher-level functional capacity, scores for Social Role (–0.69 ± 1.11, $p < 0.001$ in participants aged < 65 years ; –0.70 ± 1.16, $p < 0.001$ in participants aged ≥ 65 years) decreased significantly in both age groups. In participants aged ≥ 65 years, scores for Instrumental Self-Maintenance (–0.05 ± 0.27, $p = 0.003$) decreased significantly.

Time spent viewing television (0.42 ± 1.10 [hours / day], $p < 0.001$ in participants aged < 65 years ; 0.49 ± 1.35 [hours / day], $p < 0.001$ in participants aged ≥ 65 years) increased significantly in both age groups. Frequency of going out (–1.02 ± 3.21 [times / week], $p < 0.001$ in participants aged < 65 years ; –0.53 ± 2.79 [times / week], $p = 0.003$ in participants aged ≥ 65 years old) and conversation with others (–0.56 ± 1.47 [times / week], $p < 0.001$ in participants aged < 65 years ; –0.63 ± 1.54 [times / week], $p < 0.001$ in participants aged ≥ 65 years) decreased significantly in both age groups. In participants aged ≥ 65 years, frequency of physical activity (–0.25 ± 1.37 [times / week], $p = 0.004$) decreased significantly.

Association of higher-level functional capacity and lifestyle factors with the COVID-19 pandemic by sex

Table 4 shows the association of higher-level functional capacity and lifestyle factors with the COVID-19 pandemic by sex. In the multivariate adjustment model, total TMIG-IC score ($p < 0.002$ in men and < 0.001 in women) and Social Role score (both $p < 0.001$ in men and women) showed significant inverse associations with the COVID-19 pandemic in both men and women.

In the multivariate adjustment model, frequency of conversation with others showed significant inverse associations with the COVID-19 pandemic in both men and women ($p = 0.004$ in men and < 0.001 in women). In women only, frequency of going out showed significant inverse associations with the COVID-19 pandemic ($p = 0.002$). In contrast, time spent viewing television showed significant positive associations with the COVID-19 pandemic in women ($p = 0.047$).

Association of higher-level functional capacity and lifestyle factors with the COVID-19 pandemic by age group

Table 5 shows the association of higher-level functional capacity and lifestyle factors with the COVID-19 pandemic by age group. In the multivariate adjustment model, total TMIG-IC score and Social Role score showed significant inverse associations with the COVID-19 pandemic in both age groups ($p < 0.001$ in both).

In the multivariate adjustment model, frequency of conversation with others showed significant inverse associations with the COVID-19 pandemic in both age groups ($p = 0.001$ in both). In participants aged < 65 years only, frequency of going out showed significant inverse associations with the COVID-19 pandemic ($p = 0.003$). In contrast, time spent viewing television showed significant positive associations with the COVID-19 pandemic in participants aged ≥ 65 years ($p = 0.027$).

DISCUSSION

In the present study, scores for total TMIG-IC and Social Role decreased significantly in both sexes and age groups after adjustment for various confounders. In contrast, there was no significant association of Instrumental Self Maintenance or Intellectual Activity scores with the COVID-19 pandemic. Furthermore, frequency of conversation with others decreased significantly in both sexes and age groups after adjustment for various confounders. In women and in participants age < 65 years only, frequency of going out showed significant inverse associations with the COVID-19 pandemic. In contrast, time spent viewing television showed significant positive associations with the COVID-19 pandemic in women and in participants aged ≥ 65 years.

A previous cross-sectional study of 712 Central Americans aged > 60 years showed that quarantine due to the COVID-19 pandemic had an impact on ADL (13). In another prospective study, conducted in 1,372 adults aged > 50 years in America, IADL decreased during the COVID-19 pandemic, although there was no significant association between ADL and the COVID-19 pandemic (14). These previous studies focused on the effect of the COVID-19 pandemic on lower functional capability (i.e., BADL) rather than on higher functional capabilities (i.e., Instrumental Self Maintenance, Intellectual Activity, and Social role). In the present study, we focused on the effect of the COVID-19 pandemic on higher functional capability rather than that on BADL because of the importance of maintaining high functional capability in community-dwelling older people. We found a

Table 3. Comparison of higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by age group

	Before lockdown	During lockdown	Difference during vs. before	*p*-value ‡	Increased during vs. before §	Unchanged during vs. before ¶	Decreased during vs. before ††	Decline in higher-level functional capacity ‡‡
	mean (SD)	mean (SD)	mean (SD)		n (%)	n (%)	n (%)	n (%)
Age < 65 years, n = 154								
Total TMIG-IC score (score) †	11.03 (1.93)	10.26 (2.01)	–0.77 (1.29)	<0.001	8 (5.2)	85 (55.2)	61 (39.6)	44 (28.6)
Instrumental Self-Maintenance (score) †	4.93 (0.38)	4.88 (0.36)	–0.05 (0.29)	0.052	1 (0.6)	144 (93.5)	9 (5.8)	9 (5.8)
Intellectual Activity (score) †	3.31 (0.95)	3.28 (0.95)	–0.03 (0.29)	0.166	4 (2.6)	141 (91.6)	9 (5.8)	0 (0.0)
Social Role (score) †	2.79 (1.25)	2.1 (1.34)	–0.69 (1.11)	<0.001	6 (3.9)	89 (57.8)	59 (38.3)	38 (24.7)
Television viewing (hours / day)	3.97 (2.77)	4.4 (3.05)	0.42 (1.10)	<0.001	41 (26.6)	108 (70.1)	5 (3.2)	–
Sleep (hours / day)	6.49 (1.10)	6.51 (1.18)	0.01 (0.50)	0.747	13 (8.4)	133 (86.4)	8 (5.2)	–
Physical activity (times / week)	1.92 (2.36)	2.06 (2.72)	0.14 (1.61)	0.272	21 (13.6)	112 (72.7)	21 (13.6)	–
Going out (times / week)	4.98 (3.93)	3.96 (2.54)	–1.02 (3.21)	<0.001	8 (5.2)	88 (57.1)	58 (37.7)	–
Conversation with others (times / week)	1.08 (1.80)	0.52 (1.01)	–0.56 (1.47)	<0.001	3 (1.9)	102 (66.2)	49 (31.8)	–
Age ≥ 65 years, n = 246								
Total TMIG-IC score (score) †	11.67 (1.81)	10.94 (1.99)	–0.73 (1.31)	<0.001	8 (3.3)	85 (34.6)	61 (24.8)	60 (24.4)
Instrumental Self-Maintenance (score) †	4.94 (0.33)	4.89 (0.38)	–0.05 (0.27)	0.003	2 (0.8)	230 (93.5)	14 (5.7)	14 (5.7)
Intellectual Activity (score) †	3.47 (0.86)	3.5 (0.84)	0.03 (0.32)	0.162	13 (5.3)	227 (92.3)	6 (2.4)	1 (0.4)
Social Role (score) †	3.25 (1.14)	2.55 (1.4)	–0.7 (1.16)	<0.001	5 (2.0)	152 (61.8)	89 (36.2)	58 (23.6)
Television viewing (hours / day)	3.8 (2.35)	4.29 (2.69)	0.49 (1.35)	<0.001	78 (31.7)	159 (64.6)	9 (3.7)	–
Sleep (hours / day)	6.69 (0.87)	6.73 (0.95)	0.04 (0.39)	0.070	24 (9.8)	209 (85.0)	13 (5.3)	–
Physical activity (times / week)	3.07 (2.78)	2.81 (2.80)	–0.25 (1.37)	0.004	18 (7.3)	186 (75.6)	42 (17.1)	–
Going out (times / week)	4.85 (5.14)	4.32 (5.37)	–0.53 (2.79)	0.003	18 (7.3)	142 (57.7)	86 (35.0)	–
Conversation with others (times / week)	1.59 (2.15)	0.95 (1.54)	–0.63 (1.54)	<0.001	12 (4.9)	146 (59.3)	88 (35.8)	–

† Score ranges of total TMIG-IC score, Instrumental Self-Maintenance, Intellectual Activity, and Social Role were 0–13, 0–5, 0–4, and 0–4, respectively.
‡ Paired *t*-test.
§ Corresponds to participants with Δ higher-level functional capacity > 0.
¶ Corresponds to participants with Δ higher-level functional capacity = 0.
†† Corresponds to participants with Δ higher-level functional capacity < 0.
‡‡ Decline in total TMIG-IC score, Instrumental Self-Maintenance, Intellectual Activity, and Social Role during the COVID-19 pandemic was defined as a > 2-point, 1-point, 2-point, and 2-point decrease in score, respectively.

decrease in score for Social Role, which is considered the highest capability among the higher functional capabilities ; however, there was no effect on Instrumental Self Maintenance or Intellectual Activity scores (Tables 4 and 5). Although people were asked to refrain from going out, an early COVID-19-related lockdown was not implemented in Japan. Therefore, our results might indicate that cognitive abilities (as indicated by intellectual activity and/or the ability to carry out daily activities such as shopping for food) were maintained during the COVID-19 pandemic, and that the score for Social Role indicated less involvement with friends and family. To assess the impact of functional capacity on lifestyle factors related to functional capacity, we also assessed change in lifestyle behavior during the COVID-19 pandemic (Tables 4 and 5). Frequency of conversation with others was lower during than before the COVID-19 pandemic in both sexes and in both age groups. Frequency of going out had a significant inverse association with the COVID-19 pandemic in women and in participants aged < 65 years. In Japan, as people aged < 65 years usually are engaged in some kind of employment or labor, the effects of behavior restrictions during COVID-19 pandemic might have been greater among this demographic than among the older population aged ≥ 65 years. A previous study has reported that impairment of ADL significantly reduced the frequency of real-time contact and written contact with family and friends (16). Social behavior (e.g., going out, interacting with others, and social participation) has been reported to be a crucial factor in maintaining the health of older people (17). Residents in a community with high rates of civic participation were reported to have a significantly lower risk of IADL decline over a 3-year period (18). In addition, with regard to social participation, compared to older people who meet with friends and/or family "every day", those who do so less often than once a month were reported to have significantly higher risk of dementia and early death (19). Therefore, there is a possibility that during the COVID-19 pandemic in Japan, Social Role has decreased due to the decrease in interactions with others, such as chatting and/or going out with friends and family.

Among the higher functional capabilities, scores for Instrumental Self Maintenance and Intellectual Activity were unaffected by the COVID-19 pandemic (Table 3). Many actions associated with Intellectual Activity can be done at home (e.g., filling out pension forms, reading newspapers, books, and magazines, and watching news stories or programs). Thus, despite the limitations placed on normal life due to the COVID-19 pandemic, older people can still maintain their engagement in activities such as reading and writing that can be done at home. In fact, time spent viewing television showed significant positive associations with the COVID-19 pandemic in women and

Table 4. Higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by sex

	Age-adjusted model †			Multivariable-adjusted model ‡, §		
	Before lockdown mean (95%CI)	During lockdown mean (95%CI)	*p*-value	Before lockdown mean (95%CI)	During lockdown mean (95%CI)	*p*-value
Men, n = 200						
Total TMIG-IC score (score)	10.93 (10.64–11.22)	10.33 (10.04–10.61)	0.003	10.93 (10.66–11.20)	10.32 (10.05–10.60)	<0.002
Instrumental Self-Maintenance (score)	4.90 (4.83–4.96)	4.85 (4.79–4.91)	0.318	4.90 (4.83–4.96)	4.85 (4.79–4.91)	0.312
Intellectual Activity (score)	3.75 (3.14–3.41)	3.28 (3.15–3.41)	0.958	3.28 (3.15–3.40)	3.28 (3.16–3.40)	0.971
Social Role (score)	2.76 (2.57–2.95)	2.20 (2.01–2.38)	<0.001	2.76 (2.58–2.95)	2.19 (2.01–2.38)	<0.001
Television viewing (hours / day)	3.70 (3.35–4.05)	4.06 (3.71–4.40)	0.158	3.70 (3.36–4.04)	4.06 (3.71–4.40)	0.152
Sleep (hours / day)	6.65 (6.51–6.78)	6.67 (6.53–6.80)	0.840	6.65 (6.51–6.78)	6.66 (6.53–6.80)	0.851
Physical activity (times / week)	2.64 (2.25–3.02)	2.66 (2.28–2.98)	0.928	2.64 (2.26–3.01)	2.66 (2.29–3.04)	0.926
Going out (times / week)	5.04 (4.23–5.85)	4.53 (3.72–5.33)	0.375	5.04 (4.43–5.84)	4.53 (3.73–5.32)	0.368
Conversation with others (times / week)	1.00 (0.81–1.18)	0.63 (0.44–0.81)	0.006	1.00 (0.82–1.18)	0.62 (0.44–0.80)	0.004
Women, n = 200						
Total TMIG-IC score (score)	11.91 (11.68–12.14)	11.03 (10.80–11.26)	<0.001	11.90 (11.67–12.12)	11.04 (10.82–11.27)	<0.001
Instrumental Self-Maintenance (score)	4.90 (4.83–4.90)	4.85 (4.79–4.91)	0.025	4.98 (4.95–5.01)	4.93 (4.89–4.96)	0.240
Intellectual Activity (score)	3.55 (3.44–3.65)	3.55 (3.44–3.66)	0.948	3.54 (3.44–3.64)	3.56 (3.45–3.66)	0.833
Social Role (score)	3.39 (3.22–3.55)	2.56 (2.39–2.72)	<0.001	3.38 (3.22–3.54)	2.56 (2.41–2.72)	<0.001
Television viewing (hours / day)	4.03 (3.64–4.42)	4.61 (4.21–5.00)	0.042	4.05 (3.97–4.42)	4.59 (4.21–4.96)	0.047
Sleep (hours / day)	6.58 (6.44–6.72)	6.63 (6.48–6.77)	0.660	6.58 (6.44–6.72)	6.62 (6.48–6.77)	0.682
Physical activity (times / week)	2.62 (2.25–2.98)	2.39 (2.03–2.76)	0.392	2.61 (2.25–2.97)	2.40 (2.03–2.76)	0.418
Going out (times / week)	4.76 (4.35–5.17)	3.84 (3.43–4.25)	0.002	4.74 (4.34–5.15)	3.86 (3.46–4.26)	0.002
Conversation with others (times / week)	1.79 (1.52–2.06)	0.95 (0.67–1.22)	<0.001	1.78 (1.51–2.05)	0.96 (0.68–1.23)	<0.001

Data are presented as adjusted mean (95% confidence interval).

† Age-adjusted general linear model was used. The independent variable was the COVID-19 pandemic. The dependent variable was higher-level functional capacity or lifestyle factors.

‡ Multivariable-adjusted general linear model was used. The independent variable was the COVID-19 pandemic. The dependent variable was higher-level functional capacity or lifestyle factors.

§ When a generalized linear model was used for higher-level functional capacity or lifestyle factors except for physical activity, adjustments were performed for age, area, living status, education level, annual household income, smoking habit, drinking habit, physical activity, and body weight. When a generalized linear model was used for physical activity alone, adjustments were performed for age, area, living status, education level, annual household income, smoking habit, drinking habit, and body weight.

participants aged ≥ 65 years (Tables 4 and 5). Although there is no information regarding the types of programs that were viewed on television, it is possible that older people, especially women and participants aged ≥ 65 years, were watching news stories or programs that included health information. Instrumental Self Maintenance also encompasses many activities performed as part of basic daily activities (e.g., using public transportation, shopping for daily necessities, preparing meals, and paying bills). In a previous study conducted among the present population, the frequency of eating out during the COVID-19 pandemic was significantly lower in both sexes, whereas the frequency of eating self-cooked meals was higher (20). Because the COVID-19-related measures in Japan did not involve a strict lockdown, it was possible for people to go out to shop for daily necessities and thus to prepare their own meals. Accordingly, the pandemic did not affect Instrumental Self Maintenance in Japanese older people.

There are some limitations to the present study. First, given their observational nature, the results of the cross-sectional analyses do not allow for confirmation of a causal relationship between higher-level functional capacity and restrictions due to COVID-19. Second, there is a possibility of sampling error because we conducted an Internet panel survey. Participants were recruited from a population registered with ASMARQ Co., Ltd. and had agreed to participate in a study exploring health and lifestyle behaviors. Therefore, it is possible that the study population was biased toward individuals who were interested in health and lifestyle behaviors. The proportion of older people with an educational background of university graduation or higher was 48.8%. Therefore, it is possible that the study population was more highly educated than the general population of the same age group, with this population possibly being more health conscious than the general older population (21). Finally, while the relationships of higher-level functional capacity and lifestyle with the COVID-19 pandemic were robust after controlling for various potentially important confounders, there may have been other confounding factors that were not completely eliminated.

The present results suggest that among older Japanese people, the COVID-19 pandemic was associated with a decrease in higher-level functional capacity, particularly in terms of Social Role and the frequency of conversation with others. Functional capacity includes higher functional capabilities and BADL, among which higher functional capabilities begin to decline first, followed by a decline in BADL (22, 23). Our results might mean that the COVID-19-related early voluntary compliance with behavioral restrictions was related to the early stages of decline in higher-level functional capacity (especially for Social Role, which forms the most important aspect of higher-level functional

Table 5. Higher-level functional capacity and lifestyle factors before and during the COVID-19 pandemic by age group

	Sex-adjusted model †			Multivariable-adjusted model ‡, §		
	Before lockdown mean (95%CI)	During lockdown mean (95%CI)	*p*-value	Before lockdown mean (95%CI)	During lockdown mean (95%CI)	*p*-value
Age < 65 years, n = 154						
Total TMIG-IC score (score)	11.02 (10.71–11.33)	10.25 (9.95–10.56)	0.001	10.55 (9.93–11.18)	9.77 (9.15–10.40)	<0.001
Instrumental Self-Maintenance (score)	4.93 (4.87–4.99)	4.88 (4.82–4.94)	0.278	4.97 (4.84–5.10)	4.93 (4.80–5.05)	0.255
Intellectual Activity (score)	3.31 (3.16–3.46)	3.28 (3.13–3.43)	0.762	2.88 (2.59–3.16)	2.84 (2.55–3.13)	0.662
Social Role (score)	2.78 (2.58–2.99)	2.09 (1.89–2.30)	<0.001	2.70 (2.28–3.12)	2.01 (1.59–2.43)	<0.001
Television viewing (hours / day)	3.97 (3.51–4.43)	4.39 (3.93–4.85)	0.201	6.14 (5.22–7.05)	6.57 (5.65–7.49)	0.130
Sleep (hours / day)	6.49 (6.31–6.67)	6.51 (6.33–6.69)	0.920	6.75 (6.37–7.13)	6.76 (6.38–7.14)	0.936
Physical activity (times / week)	1.93 (1.53–2.33)	2.07 (1.67–2.47)	0.621	3.07 (2.29–3.85)	3.21 (2.43–3.99)	0.562
Going out (times / week)	4.99 (4.47–5.51)	3.97 (3.45–4.49)	0.006	4.57 (3.46–5.68)	3.53 (2.42–4.64)	0.003
Conversation with others (times / week)	1.08 (0.85–1.31)	0.52 (0.29–0.75)	0.001	1.28 (0.78–1.77)	0.71 (0.21–1.20)	0.001
Age ≥ 65 years, n = 246						
Total TMIG-IC score (score)	11.68 (11.45–11.9)	10.95 (10.72–11.17)	<0.001	11.11 (10.59–11.62)	10.41 (9.9–10.93)	<0.001
Instrumental Self-Maintenance (score)	4.94 (4.90–4.99)	4.89 (4.85–4.94)	0.100	4.91 (4.80–5.02)	4.86 (4.75–4.97)	0.098
Intellectual Activity (score)	3.47 (3.37–3.58)	3.50 (3.40–3.61)	0.702	3.00 (2.78–3.23)	3.05 (2.82–3.27)	0.484
Social Role (score)	3.26 (3.10–3.41)	2.55 (2.40–2.71)	<0.001	3.20 (2.83–3.56)	2.51 (2.14–2.87)	<0.001
Television viewing (hours / day)	3.8 (3.49–4.11)	4.29 (3.98–4.61)	0.030	3.54 (2.81–4.27)	4.01 (3.28–4.74)	0.027
Sleep (hours / day)	6.69 (6.57–6.80)	6.73 (6.62–6.84)	0.585	6.61 (6.34–6.88)	6.66 (6.39–6.94)	0.502
Physical activity (times / week)	3.07 (2.72–3.41)	2.81 (2.47–3.16)	0.315	2.17 (1.34–3.00)	1.92 (1.10–2.75)	0.306
Going out (times / week)	4.85 (4.19–5.5)	4.32 (3.66–4.97)	0.264	4.43 (2.86–6.00)	3.93 (2.36–5.51)	0.277
Conversation with others (times / week)	1.59 (1.36–1.82)	0.96 (0.73–1.19)	<0.001	1.77 (1.24–2.30)	1.17 (0.64–1.71)	0.001

Data are presented as adjusted mean (95% confidence interval).

† Sex-adjusted general linear model was used. The independent variable was the COVID-19 pandemic. The dependent variable was higher-level functional capacity or lifestyle factors.

‡ Multivariable-adjusted general linear model was used. The independent variable was the COVID-19 pandemic. The dependent variable was higher-level functional capacity or lifestyle factors.

§ When a generalized linear model was used for higher-level functional capacity or lifestyle factors except for physical activity, adjustments were performed for sex, area, living status, education level, annual household income, smoking habit, drinking habit, physical activity, and body weight. When a generalized linear model was used for physical activity alone, adjustments were performed for sex, area, living status, education level, annual household income, smoking habit, drinking habit, and body weight.

capacity in the context of our study). We could not examine the effects of long-term voluntary compliance with behavioral restrictions exceeding one year in our study, although a previous longitudinal study has shown such an effect on IADL reduction (14). Longer-term voluntary compliance with behavioral restrictions may affect not only Social Role but also Instrumental Self Maintenance, Intellectual Activity, and ADL. Further, larger studies are needed to assess the impact of restrictions on social behavior on higher-level functional capacity and ADL.

CONFLICT OF INTEREST

All authors state that they have no conflicts of interest.

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CONTRIBUTIONS

Mariko Nakamoto : Conceptualization, Methodology, Data curation, Writing- Original draft preparation ; Koki Torami : Data curation, Writing- Reviewing ; Miku Kanmura : Data curation, Writing- Reviewing ; Mai Yoshida : Data curation, Writing-Reviewing ; Akiko Nakamoto : Writing- Reviewing and Editing ; Tohru Sakai : Supervision, Writing- Reviewing and Editing

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Supplemental table 1. Population composition ratios

	Men	Women
Hokkaido	770,021 (4.4)	946,224 (4.8)
Tohoku	1,329,830 (7.7)	1,524,448 (7.7)
Kanto	5,595,586 (32.3)	6,197,292 (31.3)
Chubu	2,977,781 (17.2)	3,331,333 (16.8)
Kansai	3,018,525 (17.4)	3,535,658 (17.9)
Chugoku / Shikoku	1,623,925 (9.4)	1,887,543 (9.5)
Kyushu	2,007,020 (11.6)	2,348,801 (11.9)
Total	17,322,688 (100)	19,771,299 (100)

Data are presented as the number (%).
National data based on "Basic Resident Registration by Age and Prefecture on January 1, 2021".[24]