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The effect of modifiable healthy practices on higher-level functional capacity decline among Japanese community dwellers

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ABSTRACT

This study aimed to clarify the effects of the accumulation of 8 modifiable practices related to health, including smoking, alcohol drinking, physical activity, sleeping hours, body mass index, dietary diversity, *ikigai* (life worth living), and health checkup status, on higher-level functional capacity decline among Japanese community dwellers. Data were derived from the National Institute for Longevity Sciences - Longitudinal Study of Aging. Subjects comprised 1269 men and women aged 40 to 79 years at baseline (1997–2000) who participated in a follow-up postal survey (2013). Higher-level functional capacity was measured using the Tokyo Metropolitan Institute of Gerontology Index of Competence (total score and 3 subscales: instrumental self-maintenance, intellectual activity, and social role). The odds ratio (OR) and 95% confidence interval (CI) for a decline in higher-level functional capacity in the follow-up study according to the total number of healthy practices were analyzed using the lowest category as a reference. Multivariate adjusted ORs (95% CIs) for the total score of higher-level functional capacity, which declined according to the total number of healthy practices (0–4, 5–6, 7–8 groups) were 1.00 (reference), 0.63 (0.44–0.92), and 0.54 (0.31–0.94). For the score of social role decline, multivariate adjusted ORs (95% CIs) were 1.00 (reference), 0.62 (0.40–0.97), and 0.46 (0.23–0.90), respectively (P for trend = 0.04). Having more modifiable healthy practices, especially in social roles, may protect against a decline in higher-level functional capacity among middle-aged and elderly community dwellers in Japan.

1. Introduction

In today's aging society, we face the serious concern of extending the healthy lifespan of the elderly. Higher level competencies, such as social role and instrumental self-maintenance, usually deteriorate before declines in basic activities of daily living (Koyano et al., 1991). To extend the healthy life expectancy, it is important to prevent a loss of higher-level competencies in later life.

Numerous factors affect disability (May et al., 2015), and a systematic analysis selected 67 risk factors of disease burden in 21 regions in the world (Lim et al., 2012). Some lifestyle-related factors, including smoking, alcohol drinking, low physical activity, and low fruit intake, were selected as major risk factors for disability in the more wealthy Asia Pacific region (Lim et al., 2012). Among these factors, higher physical activity or physical ability, such as handgrip strength or walking speed, were associated with higher levels of competence (Nakamoto et al., 2015; Sugiura et al., 2013). Although a few investigations have reported the negative effects of smoking, longer sleep duration, poor self-rated health, lower animal protein intake, personality traits, and lower social participation on higher levels of competence (Imai et al., 2014; Tomioka et al., 2015; Tsubota-Utsugi et al., 2014), the impact of other lifestyle-related factors on loss of higher levels of competence is not well understood. In addition, it is not clear whether an accumulation of healthy lifestyle-related factors within individuals, as measured by the total number of healthy practices, is associated with higher levels of competence.

In this study, we analyzed the effect of an accumulation of 8 selected practices, including smoking, alcohol drinking, physical activity, sleeping hours, body mass index (BMI), dietary diversity, *ikigai* (life

Abbreviations: BMI, body mass index; CI, confidence interval; NILS-LSA, National Institute for Longevity Sciences - Longitudinal Study of Aging; OR, odds ratio; QUANTIDD, Quantitative Index for Dietary Diversity; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.

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worth living (Sone et al., 2008)), and health checkup status on higher-level functional capacity decline among Japanese community dwellers. We selected these 8 practices because they are modifiable health-related factors.

2. Methods

2.1. Study subjects

Data for this survey were collected as part of the National Institute for Longevity Sciences - Longitudinal Study of Aging (NILS-LSA). Participants in the NILS-LSA included randomly selected age- and sex-stratified individuals from the pool of non-institutionalized residents in the NILS neighborhood areas of Obu City and Higashiura Town in Aichi Prefecture, located in central Japan. The first wave (baseline study) of the NILS-LSA (1997–2000) comprised 2267 participants (1139 men, 1128 women; aged 40–79 years). Details of the NILS-LSA study have been reported elsewhere (Shimokata et al., 2000).

In August 2013, a self-administered questionnaire was sent by mail to assess health status. After excluding participants who died (identified through the Basic Resident Registry or information from families), questionnaires were sent to 1933 individuals out of the 2267 baseline participants. A total of 1462 respondents (76% collection rate) replied, including 171 participants in their 50s, 495 in their 60s, 444 in their 70s, and 352 in their 80s or 90s in 2013. Apart from the 1462 respondents, the breakdown of the 471 individuals who did not respond was as follows: death (24 deaths reported on returned questionnaire), withdrawal (1), address unknown (33) and no reply (413).

Of the 1462 respondents, we excluded subjects with lack of data in any of the following variables: higher-level functional capacity at baseline and/or follow-up survey ($n = 44$); lifestyle-related factors ($n = 68$); and potential cofounders at baseline ($n = 81$), including household annual income, education, and history of stroke, hyperlipidemia, diabetes, hypertension, heart disease, cancer, osteoporosis, rheumatoid arthritis, and dementia. Thus, 1269 subjects (624 men, 645 women) were available for analysis.

The study protocol was reviewed and approved by the Committees of Ethics of Human Research of the National Center for Geriatrics and Gerontology (No. 640-2). Written informed consent was obtained from all subjects during the baseline study. In the mailed survey in 2013, we explained that returning the self-administered questionnaire represented informed consent.

2.2. Higher-level functional capacity

Higher-level functional capacity was assessed using the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) at baseline and follow-up survey (Koyano et al., 1991). It is a multidimensional evaluation method consisting of 13 items with the following 3 subscales: instrumental self-maintenance (5 items), intellectual activity (4 items), and social role (4 items). Each 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. According to a previous report (Fujiwara et al., 2003), we defined a decline in higher-level functional capacity as follows: 1) a decrease of ≥2 points in total score for higher-level functional capacity, 2) a decrease of ≥1 point in score for instrumental self-maintenance, 3) a decrease of ≥2 points in score for intellectual activity, or 4) a decrease of ≥2 points in score for social role.

2.3. Healthy practices

Information was gathered from physical examinations, dietary assessments, and self-administered questionnaires with reference to healthy practices, as proposed by Breslow and Breslow (1993), the Global Burden of Disease Study 2010, and studies focused on health checkups among Japanese (Seino et al., 2014; Suka et al., 2009). In addition, we added "*ikigai*" (life worth living (Sone et al., 2008)), that is, "one aspect of psychological well-being to judge one's life as meaningful and worth living" (Yamamoto-Mitani and Wallhagen, 2002) as a psychological factor. All health-related measurements were assessed in the baseline survey.

Ikigai (life worth living) was assessed in a self-reported questionnaire asking whether the subject has or does not have *ikigai* for at least one objective (work; connection with colleagues in work place; connection with family members; child/children or grandchildren; hobbies or sports; keeping company with friends while participating in hobbies; activities in a local area or a group activity; caring for another person; religion; or other). Health checkup status was assessed in a self-reported questionnaire asking whether the subject had a health checkup once a year or less than that (never/once in 2 or 3 years). Dietary diversity and alcohol intake were assessed using a 3-day (2 weekdays and 1 weekend day) dietary record (Imai et al., 2000) and determined using the Quantitative Index for Dietary Diversity (QUANTIDD) (Katanoda et al., 2006). The index ranges from 0 to 1. Lower scores indicate an unbalanced diet, and higher scores indicate an equal distribution of each food group.

BMI was calculated as weight in kilograms divided by the square of height in meters. Physical activity was assessed by the METs score (a multiple of the resting metabolic rate), obtained through participant interviews with trained interviewers using a semi-quantitative assessment method to assess participants' levels of habitual physical activity during leisure time and on the job, and their sleeping hours (Kozakai et al., 2012).

Follow-up time (year) was calculated by the length of time (days) that had elapsed since the day each subject participated in the baseline survey to 19 July 2013 (the deadline for the follow-up postal survey).

2.4. Statistical analysis

All statistical analyses were conducted using Statistical Analysis System software version 9.3 (SAS Institute, Cary, NC, USA). Each of the 8 lifestyle factors was categorized into 'unhealthy (0 points)' or 'healthy (1 point)' practices as follows: (1) smoking status: past/current or never; (2) alcohol drinking: ≥23 g ethanol per day or <23 g ethanol per day (Shimazu et al., 2012); (3) physical activity: below or above the median of METs * h per day, as follows: <32 or ≥32 METs * h per day; (4) sleeping hours: <6 or ≥8 h per day or ≥6 –<8 h per day; (5) BMI: <21.5 or ≥25 kg/m^2 or ≥21.5–<25 kg/m^2 according to dietary goals for the elderly of the Japanese dietary guidelines 2015 (Ministry of Health, Labor and Welfare, 2015); (6) dietary diversity: below or above the sex-stratified median of QUANTIDD, as follows: men: 0.50–0.88 ($n = 322$) or 0.88–0.95 ($n = 322$); women: 0.74–0.90 ($n = 333$) or 0.90–0.96 ($n = 333$); (7) *ikigai*: 'None or one' or 'Have at least 2 positive responses to specified items'; and (8) health checkup status: never checked/once in 2 or 3 years or once a year. The total number of healthy practices was obtained by adding the number of healthy practices. Subjects were classified into 3 groups by the total number of healthy practices, that is, 0 to 4, 5 to 6, and 7 to 8, as only a few subjects had a lower or higher total number of healthy practices.

Differences in proportions and continuous variables according to the total number of healthy practices were assessed using the chi-square test or Fisher's exact probability test (if statistical expectation was ≤5) and the general linear model, respectively.

Multiple logistic regression analysis was performed to estimate the odds ratio (OR) and 95% confidence interval (CI) for higher-level functional capacity decline (total score and 3 subscale scores) according to the total number of healthy practices. The lowest category was used as a reference. The adjustment variables (confounding variables) were age, sex, individual subscale scores at baseline, household annual income, education, and history of stroke, hyperlipidemia, diabetes,

hypertension, and heart disease. All reported *P* values were two-sided, and a *P* value <0.05 was considered significant.

3. Results

A total of 1269 subjects were included in the study. Mean (SD) follow-up time was 14.3 (0.6) years. A total of 196 (15%), 126 (10%), 62 (4%), and 129 (10%) subjects showed a decline in the total score for higher-level functional capacity (a decrease ≥2 points), instrumental self-maintenance (a decrease ≥1 point), intellectual activity (a decrease ≥2 points), and social role (a decrease ≥2 points).

The number of women increased as the total number of healthy practices increased (<0.01) and TMIG-IC total scores and scores on 3 subscales at baseline were higher as the number of healthy practices increased ($P < 0.05$) (Table 1). Participating in physical activity (≥-32 METs * hr/day), moderate sleeping hours (≥6- < 8 h per day), or having *ikigai* (life worth living) for at least 2 positive variables was negatively associated with the total score of higher-level functional capacity decline (data not shown). In Table 2, the total number of healthy practices was negatively associated with the risk for a decline in higher-level functional capacity, except for instrumental self-maintenance.

In a sub-analysis, information on patients who dropped out due to death ($n = 328$ baseline subjects) was obtained from the National Vital Statistics records until 2014 (provided by the Ministry of Health, Labour, and Welfare). Healthy practices among these subjects (deaths) at baseline were relatively low, with distributions of 49%, 42%, and 9% for 0–4, 5–6, and 7–8 healthy practices, respectively. Therefore, unhealthy behaviors at baseline and vitality were strongly associated.

4. Discussion

This study provides longitudinal evidence over a 14-year period in community-dwelling Japanese that the accumulation of healthy practices was negatively associated with the risk for a decline in higher-level functional capacity, especially in social role. To our knowledge, this is the first report suggesting that cultivating healthier practices could lead to maintaining higher-level functional capacity.

In previous studies among Japanese subjects, physical activity or physical ability (Nakamoto et al., 2015; Sugiura et al., 2013), social capital (engagement in a cohesive group) (Kondo et al., 2007), self-rated health (Sugiura et al., 2011), and personality traits of lower psychoticism and higher extraversion (Tsubota-Utsugi et al., 2014) were significantly associated with higher levels of competence. These results indicate not only physical or social activity but also current health are associated with future competence, and subjects with higher extraversion tend to decide to and have healthier practices (Tsubota-Utsugi et al., 2014). To maintain a moderate body weight or have an annual health checkup might mean that a subject is more health conscious, eats a variety of foods, takes part in physical activity, and practices better drinking or sleeping habits, which results in better physical and psychological health (Breslow and Breslow, 1993). Additionally, a higher "*ikigai* (life worth living)" score reflects a more positive psychological profile and better adaptation to the environment, and contributes to positive effects on higher-level functional capacity (Nakanishi, 1999; Nakanishi et al., 1998). Interestingly, each healthy practice was positively or not positively associated with higher-level functional capacity; however, the accumulation of these practices had a favorable effect on social role capacity.

The other sub-scales, including instrumental self-maintenance and intellectual activity, did not show a dose-response associated with healthy practices at baseline. Fujiwara et al. (2003) reported that subjects who had no initial disability were most likely to lose social role function with advancing age among the 3 TMIG-IC subscales. Therefore, results of this study, indicating that there was only a positive effect on social role function, are reasonable.

The ORs (95% CIs) for the total score of higher-level functional capacity, which declined in 5–6 or 7–8 healthy practice groups in reference to the lowest groups (0–4 healthy practices), were 0.63 (0.44–0.92) and 0.54 (0.31–0.94), respectively. If there was an ideal level among the number of healthy practices within this study, having 5 or more healthy practices might have a favorable effect on competence. However, having 5 or more healthy practices might be a difficult goal for many patients and will depend on the individual. When we re-categorized the number of healthy practices with exploratory analyses (multiple comparison), having 2 or more healthy practices rather than 0–1, or having 3 or more healthy practices rather than 0–2, resulted in better protection against a decline in functional capacity. This finding suggests that having more healthy practices, even among people with relatively few healthy practices, may help maintain a higher level of functional capacity.

Several limitations to the present study warrant consideration. First, participants in this study were randomly selected age- and sex-stratified non-institutionalized individuals from the community, but their health status or concerns might be higher than non-participants. In fact, 80.2% of subjects had an annual health checkup at baseline, which was a relatively high rate compared with a recent report (30–40% among community dwellers) (Miyagawa et al., 2014). Participants in medical checkups within the last year generally have healthier life practices and more often rate their own health as good or normal compared with non-participants (Mitsuhashi et al., 2003). In addition, deaths occurred during follow-up in almost 300 cases of the 2300

Table 1
Baseline characteristics of subjects according to the total number of healthy practices in the National Institute for Longevity Sciences - Longitudinal Study of Aging, Japan (1997–2000).

	Total number of healthy practices at baseline ($n = 1269$)				
	0–4 ($n = 378$)	5–6 ($n = 656$)	7–8 ($n = 235$)	P-value[a]	Trend P-value[b]
Age (mean ± SD, years)	56.6 ± 10.3	56.6 ± 9.4	54.9 ± 8.7	0.05	0.03
Women (%)	24.5	53.5	81.3	<0.01	<0.01
Education, ≤9 years (%)	25.7	29.3	25.5	0.35	0.83
Household annual income, <4.500,000 yen (%)	24.3	20.4	19.2	0.22	0.10
History of stroke (yes, %)	1.9	1.7	0.9	0.60	0.56
History of hyperlipidemia (yes, %)	14.6	16.3	19.6	0.26	0.11
History of diabetes (yes, %)	7.1	4.6	5.5	0.22	0.27
History of hypertension (yes, %)	23.3	20.3	15.7	0.08	0.03
History of heart disease (yes, %)	10.6	9.5	5.5	0.09	0.045
Total score of higher-level functional capacity[c] at baseline (mean ± SD)	12.2 ± 1.2	12.5 ± 1.0	12.7 ± 0.7	<0.01	<0.01
Score of instrumental self-maintenance (mean ± SD)	4.9 ± 0.4	4.9 ± 0.3	5.0 ± 0.2	<0.01	<0.01
Score of intellectual activity (mean ± SD)	3.8 ± 0.5	3.8 ± 0.5	3.9 ± 0.4	0.03	0.01
Score of social role (mean ± SD)	3.6 ± 0.8	3.7 ± 0.6	3.8 ± 0.5	<0.01	<0.01

[a] For continuous variables, the general linear model was used; for categorical variables, the chi-square test or Fisher's exact probability test was used.
[b] For continuous variables, the general linear model was used; for categorical variables, Cochran-Armitage test was used.
[c] The score of higher-level functional capacity was calculated by the sum of 3 subscales (instrumental self-maintenance, intellectual activity, and social role).

Table 2
Odds ratios for higher-level functional capacity decline according to total number of healthy practices at baseline.

	Total number of healthy practices at baseline (n = 1269)				
	0–4 (n = 378)	5–6 (n = 656)	7–8 (n = 235)	P-value[a]	Trend P-value[b]
Total score of higher-level functional capacity[c]					
Number of subjects in whom score declined ≥2/≤1	77/301	93/563	26/209	0.03	<0.01
Multiple-adjusted OR (95% CI)[d]	1.00 (reference)	0.63 (0.44–0.92)	0.54 (0.31–0.94)	–	0.02
Score of instrumental self-maintenance					
Number of subjects in whom score declined ≥1/0	50/328	59/597	17/218	0.03	0.01
Multiple-adjusted OR (95% CI)[d]	1.00 (reference)	0.68 (0.43–1.07)	0.72 (0.37–1.41)	–	0.09
Score of intellectual activity					
Number of subjects in whom score declined ≥2/≤1	26/352	25/631	11/224	0.09	0.13
Multiple-adjusted OR (95% CI)[d]	1.00 (reference)	0.49 (0.26–0.90)	0.66 (0.29–1.50)	–	0.02
Score of social role					
Number of subjects in whom score declined ≥2/≤1	52/326	62/594	15/220	<0.01	<0.01
Multiple-adjusted OR (95% CI)[d]	1.00 (reference)	0.62 (0.40–0.97)	0.46 (0.23–0.90)	–	0.04

OR, odds ratio; CI, confidence interval.
[a] χ^2 test was used.
[b] Cochran-Armitage test was used.
[c] The score of higher-level functional capacity was calculated by the sum of 3 subscales (instrumental self-maintenance, intellectual activity, and social role).
[d] Adjusted for age, sex, individual subscale scores at baseline, household annual income, education, and history of stroke, hyperlipidemia, diabetes, hypertension, and heart disease.

participants at baseline. In a sub-analysis, information on patients who dropped out due to death (n = 328 baseline subjects) was obtained from the National Vital Statistics records until 2014 (provided by the Ministry of Health, Labour, and Welfare). Healthy practices among these subjects (deaths) at baseline were relatively low, with distributions of 49%, 42%, and 9% for 0–4, 5–6, and 7–8 healthy practices, respectively. Therefore, unhealthy behaviors at baseline and vitality were strongly associated. In fact, a history of hypertension and heart disease among study subjects was associated with unhealthy behaviors (Table 1). Second, we assessed health practices from self-reported questionnaires or physical assessments only at baseline. Healthy practices such as shorter sleeping hours, weight loss (loss of body mass), and lower physical activity change with age (Montgomery and Dennis, 2002; Zhu et al., 2010). Thus a loss in the total number of healthy practices might be inevitable among the elderly. However, some practices such as having *ikigai* (life worth living) or eating a variety of foods are changeable practices when someone has an incentive to improve health, even in the elderly. Third, some variables we chose in this study might not be the best indicators of individual health practices. For example, the METs score is not widely understood in the community; therefore, it would be better to assess walking hours or number of daily steps. Considering more appropriate or modifiable life-style related practices depends in the ethnicity or culture would be helpful; thus, future studies that address these factors are needed.

Although not all healthy practices were positively associated with higher-level functional capacity, the accumulation of good practices within individuals was associated with higher-level functional capacity. These results suggest that more healthy practices may help people maintain functional capacity, which may contribute to future better health and less disability.

In conclusion, our results indicate that modifying unhealthy practices, one by one, and maintaining good health practices should be recommended even in community dwellers as a strategy to prevent a decline in higher-level functional capacity.

Conflicts of interest

None.

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