Prospective Study of Engagement in Leisure Activities and All-Cause Mortality Among Older Japanese Adults

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ABSTRACT

Background: Engagement in leisure activities among older people is associated with a lower risk of mortality. However, no studies have been conducted focusing on the difference of associations with mortality risk among multiple types of leisure activities.

Methods: We examined prospectively the association of engagement in leisure activities with all-cause mortality in a cohort of older Japanese adults. The Japan Gerontological Evaluation Study included 48,216 participants aged 65 years or older. During a mean follow-up period of 5.6 years, we observed 5,575 deaths (11.6%). We investigated the total number of leisure activities, as well as combinations of 25 different leisure activities with Cox proportional hazards models, adjusting for potential confounding factors.

Results: We found a linear relationship between the total number of leisure activities and mortality hazard (adjusted hazard ratio, 0.93; 95% CI, 0.92–0.95). Furthermore, engagement in leisure activities involving physical activity, as well as group-based interactions, showed the strongest associations with lowered mortality. By contrast, engagement in cultural leisure activities and solitary leisure activities were not associated with all-cause mortality.

Conclusion: Although we cannot rule out residual confounding, our findings suggest that encouraging engagement in physically-active group-based leisure activities may promote longevity in older adults.

Key words: aging; leisure activities; Japan; older people

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INTRODUCTION

Leisure activities have been defined as “the voluntary use of free time for activities outside the daily routine”¹ and “activities that individuals engage in for enjoyment or well being which are independent of work or activities of daily living.”² Engagement in leisure activities among older people is associated with a lower risk of mortality.³⁻⁷ There are several postulated mechanisms linking engagement in leisure activities to health. Most obviously, many leisure activities involve physical activity, and in turn, physical activity is associated with a lower risk of cardiovascular disease,⁸ cancer,⁹ diabetes,¹⁰ and cognitive decline.¹¹⁻¹³ By contrast, sedentary behavior is associated with a higher risk of chronic diseases and mortality.¹²⁻¹⁴ However, engagement in some sedentary leisure activities—for example, cognitive activities and cultural activities—has been suggested to be associated with beneficial health outcomes.¹⁵⁻²⁰

Participation in cognitively stimulating activities decreases the risk of cognitive impairment and dementia,¹¹⁻¹⁶ and dementia is associated with a higher risk of mortality.²¹ A subset of cognitively stimulating activities, cultural engagement, also has been suggested to reduce the risk of depression¹⁷ and mortality,¹⁸⁻¹⁹ as well as cognitive decline.²⁰ Finally, some leisure activities are inherently social in nature because they are conducted in groups. Engagement in social activity is also associated with many health benefits. Previous studies showed that social participation lowered the risk of dementia,¹²,²² isolation,²³ mental health problems,²⁴ and mortality.²⁵

In Japan, several studies have been conducted on the relationship between leisure activities and mortality, but the measurements of leisure activities are limited. That is, previous studies using the Japanese sample did not measure the specific leisure activities and failed to count the total number of leisure activities.⁵,²⁶ A study among 1,853 older adults residing in one prefecture of Japan only assessed whether they have any hobbies.⁶ Another study among 3,583 older adults residing in one Japanese prefecture focused only on the structural aspects of hobbies, such as physical or cultural, and solitary or group activities.²⁶ Furthermore, these studies showed inconsistent findings; the former study reported engagement in leisure activities was associated with a lower risk of mortality,⁶ whereas the latter study did not detect a significant relationship between

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METHODOLOGIC

Study Participants

The Japan Gerontological Evaluation Study (JAGES) is a nationwide, population-based cohort study established in 2010 to investigate the social determinants of healthy aging among non-disabled community-dwelling residents aged 65 years or older. The baseline survey was conducted between August 2010 and January 2012. We distributed questionnaires to 95,827 participants (22,178 men and 73,649 women). The protocol of this study was approved by the Ethics Committees of the National Center for Geriatrics and Gerontology (No. 992-3).

Outcome Variable

Our primary outcome was mortality. We retrieved information on mortality from 2010 to 2016 from the government database of the public long-term care insurance system. Among these records, there were 5,575 (11.6%) deaths identified in the analytic sample. Those who moved out of the municipalities, living in nursing homes, or missing information about their leisure activities were not included in the analytic sample.

Explanatory Variable

We evaluated participants’ engagement in leisure activities by using the following two questions, “Do you have any hobbies or take lessons? (Yes/No),” and “Which of the following are your hobbies or lessons? (mark all that apply): golf, mini golf, gate ball, exercise/Tai Chi, walking/jogging, Go/Shogi/Mahjong, reading, personal computer, PC use, playing musical instruments, chorus/folk song, karaoke, dancing, Haiku/Tanka/Senryu, calligraphy, tea ceremony/flower arrangement, craft, painting/hand-drawn postcards, photography, gardening, growing crops, traveling, hiking, fishing, pachinko, and other.” Among the free descriptive answers to leisure activities conducted in the previous JAGES survey in 2006, we selected 25 leisure activities that were often described by participants. Leisure activities with the same activity content but different activity names were combined as an option. We excluded individuals with missing answers on the baseline survey. We then constructed several alternative ways of summarizing leisure activities. For the main analyses, we defined the total number of leisure activities based on the responses: “0,” “1,” “2,” “3,” “4,” “5,” and “6 or more.” Participants who engaged in 7 or more leisure activities accounted for only 3.4% of the sample; thus, we combined this group with the participants who engaged in 6 leisure activities, to make a “6 or more” grouping.

For secondary analyses, we grouped the 25 leisure activities in two ways. First, we grouped the activities based on whether they involved predominantly “physically-active leisure activities” or “cultural leisure activities” (golf, mini golf, gate ball, exercise/Tai Chi, walking/jogging, dancing, gardening, growing crops, and hiking). “cultural leisure activities” (Go/Shogi/Mahjong, reading, playing musical instruments, chorus/folk song, Haiku/Tanka/Senryu, calligraphy, tea ceremony/flower arrangement, craft, painting/hand-drawn postcards, and photography). Second, we grouped the leisure activities according to whether they involved predominantly “group-based leisure activities” (golf, mini golf, gate ball, Go/Shogi/Mahjong, chorus/folk song, karaoke, and dancing). “solitary leisure activities” (reading, PC use, playing musical instruments, Haiku/Tanka/Senryu, calligraphy, craft, painting/hand-drawn postcards, and fishing).
Covariates

We selected as potential mediating variables frequency of meeting friends,41 number of social interactions with friends/acquaintances,42 and social support (receiving).40,42 Multiple imputations were conducted for missing data on questions to measure instrumental activities of daily living. We imputed the missing values of 13 questions regarding instrumental activities of daily living by using all the other variables used in the present analyses. We used the “mi” command of STATA (Stata Corp, College Station, TX, USA) for multiple imputation through the Markov chain Monte Carlo method and created 20 imputed datasets.

Statistical analysis

We used Cox proportional hazards models to evaluate the association of engagement in leisure activities with all-cause mortality. Model 1 adjusted for sex, age, and socioeconomic status. Model 2 additionally adjusted for the other potential confounding variables. Model 3 further adjusted for potential mediating factors; social network, and social support. The analyses were repeated by excluding the deaths occurring within the first 1, 2, and 3 years of follow-up in order to address reverse causality.

First, we assessed possible interaction by sex. When we added an interaction term between the total number of leisure activities (continuous) and sex (categorical) to the regression models, it was not statistically significant ($P = 0.76$). We also assessed possible interaction by age (categorical), and it was not statistically significant either ($P > 0.5$). Hence, we present all results combining both sex and all ages.

Besides, we computed the E-values to assess residual confounding. Although no threshold cutoff is proposed, E-values provide an assessment of how strongly an unmeasured confounding variable would need to be associated with the exposure and outcome in order to fully explain away the observed associations.39 Accordingly, larger E-values imply that substantial unmeasured confounding would be needed to explain away the observed association. E-value is calculated by using the observed hazard ratio [HR] of $HR$, and $HR^*$ = inverse of $HR$:

- when $HR > 1$, $E-value = HR + \sqrt{(HR \times (HR - 1))}$,
- when $HR < 1$, $E-value = HR^* + \sqrt{(HR^* \times (HR^* - 1))}$.

Two sets of sensitivity analyses were conducted with different classifications of leisure activities. First, we stratified the analysis by “physically-active leisure activities (golf, mini golf, gate ball, exercise/ Tai Chi, walking/jogging, dancing, gardening, growing crops, and hiking),” “sedentary leisure activities (Go/Shogi/Mahjong, chorus/folk song, karaoke, tea ceremony/flower arrangement, photography, traveling, and other),” and “the others (chorus/folk, photography, traveling, fishing, and other).”12,14 “Physically-active leisure activities” are the same as those of the earlier analysis, while “sedentary leisure activities” are slightly different from “cultural leisure activities.” For example, “PC,” “karaoke,” and “pachinko” were grouped under “sedentary leisure activities,” although they were not included in “cultural leisure activities” in the previous analysis. Secondly, we compared “physically-active group-based leisure activities (golf, mini golf, gate ball, and dancing),” “physically-active non-group-based leisure activities (exercise/Tai Chi, walking/jogging, gardening, growing crops, and hiking),” “non-physically-active non-solitary leisure activities (Go/Shogi/Mahjong, chorus/folk song, karaoke, tea ceremony/flower arrangement, photography, traveling, and other),” and “non-physically-active solitary leisure activities (reading, PC, playing musical instruments, Haiku/Tanka/Senryu, calligraphy, craft, painting/hand-drawn postcards, fishing, and pachinko).” The idea was that we would compare the four types of leisure activities, “physically-active group-based,” “physically-active non-group-based,” “non-physically-active group-based,” and “non-physically-active non-group-based” leisure activities in the light of the two analyses above.

Finally, we examined the association of each leisure activity with all-cause mortality (simultaneously mutually adjusted). All analyses were performed using Stata software (version 14.2) at a significance level of 0.05.

RESULTS

Among the eligible 48,216 participants, 5,575 (11.6%) deaths occurred over a mean of 5.6 years of follow-up or 270,311 person-years. Table 1 shows the baseline characteristics of the participants, according to the reported total number of leisure activities. 28.9% of the population had “0” leisure activity, while 54.0% had two or more leisure activities. The total number of leisure activities varied based on socioeconomic status (ie, education, income, and employment status), instrumental activities of daily living, depression score, self-rated health, social network, and social support. For example, the total number of leisure activities is more likely to be larger among those with higher socioeconomic status, male gender, married status, no cognitive complaints, better self-rated health, being socially active, and receiving social supports. The baseline characteristics of male and female participants are shown in eTable 1. Among 22,178 male participants, 3,519 (15.9%) deaths occurred, and among 26,038 female participants, 2,056 (7.9%) deaths occurred over the follow-up period.

Table 2 shows the association of the total number of leisure activities with mortality. There was a statistically significant inverse relationship between the total number of leisure activities and mortality ($P$ for linear trend <0.001). When we modeled the total number of leisure activities as a linear variable, the HRs of all-cause mortality were 0.87 (95% confidence interval [CI], 0.86–0.89) in model 1, 0.93 (95% CI, 0.92–0.95) in model 2, and 0.93 (95% CI, 0.92–0.95) in model 3. The E-values for the analyses of the association between the total number of leisure activities and all-cause mortality were calculated; $E = 1.55$ (model 1), $E = 1.35$ (model 2), and $E = 1.34$ (model 3), which are shown in eTable 2.

Table 3 shows the association of the types and the number of leisure activities in terms of physical activity involvement (“physically-active leisure activities,” “cultural leisure activities,” and “other leisure activities”) with mortality. Both “physically-
**Table 1.** Baseline characteristics of older Japanese participants (n = 48,216) who were 65 years of age or older, Japan, 2010–2016

| Characteristic          | Total number of leisure activities |
|-------------------------|-----------------------------------|
|                         | 0 (n = 13,953) | 1 (n = 8,228) | 2 (n = 8,197) | 3 (n = 6,842) | 4 (n = 4,711) | 5 (n = 2,957) | 6–17 (n = 3,328) |
|                         | No. | %   | No. | %   | No. | %   | No. | %   | No. | %   | No. | %   |
| Deaths                  |     |     |     |     |     |     |     |     |     |     |     |     |
| Male                    |     |     |     |     |     |     |     |     |     |     |     |     |
| Female                  |     |     |     |     |     |     |     |     |     |     |     |     |
| Age, years              |     |     |     |     |     |     |     |     |     |     |     |     |
| 65–69                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 70–74                   |     |     |     |     |     |     |     |     |     |     |     |     |
| 75–79                   |     |     |     |     |     |     |     |     |     |     |     |     |
| ≥80                     |     |     |     |     |     |     |     |     |     |     |     |     |
| Educational attainment, years ≤9 | 1,180 | 14.9 | 921 | 11.2 | 630 | 7.7  | 208 | 7.0  | 196 | 5.9  |     |     |
|                         | 3,862 | 27.7 | 2,408 | 29.3 | 2,618 | 31.9 | 2,543 | 37.2 | 1,827 | 38.8 | 1,279 | 43.3 |
|                         | 529 | 3.8  | 281 | 3.4  | 311 | 3.8  | 213 | 3.1  | 139 | 3.0  | 90 | 3.0 |
|                         | 9,264 | 66.4 | 5,325 | 64.7 | 5,111 | 62.4 | 4,984 | 58.2 | 2,689 | 57.1 | 1,548 | 52.4 |
|                         |     |     |     |     |     |     |     |     |     |     |     |     |
| Annual income, Japanese yen <2.0 million | 6,283 | 45.0 | 3,605 | 43.8 | 3,348 | 40.8 | 2,609 | 38.1 | 1,664 | 35.3 | 1,009 | 34.1 |
|                         | 3,629 | 26.0 | 2,127 | 25.9 | 2,580 | 31.5 | 2,483 | 36.3 | 1,890 | 40.1 | 1,208 | 40.9 |
|                         | 1,057 | 7.6  | 621 | 7.6  | 764 | 9.3  | 718 | 10.5 | 547 | 11.6 | 402 | 13.6 |
| Employment status       | 2,984 | 21.4 | 1,875 | 22.8 | 1,505 | 18.4 | 1,032 | 15.1 | 610 | 13.0 | 338 | 11.4 |
|                         |     |     |     |     |     |     |     |     |     |     |     |     |
| Marital status          | 9,290 | 66.6 | 5,509 | 67.0 | 5,784 | 70.6 | 5,002 | 73.1 | 3,542 | 75.2 | 2,255 | 76.3 |
|                         | 3,424 | 24.5 | 1,979 | 24.1 | 1,804 | 22.0 | 1,406 | 20.6 | 906 | 19.2 | 554 | 18.7 |
| Smoking status          | 539 | 3.9 | 280 | 3.4 | 269 | 3.3 | 201 | 2.9 | 129 | 2.7 | 73 | 2.5 |
| Alcohol intake          | 291 | 2.1 | 176 | 2.1 | 167 | 2.0 | 123 | 1.8 | 82 | 1.7 | 47 | 1.6 |
| BML kg/m²               | 8,921 | 63.9 | 5,361 | 65.2 | 5,562 | 67.9 | 4,832 | 70.6 | 3,434 | 71.3 | 2,168 | 73.3 |
|                           | 2,685 | 19.2 | 1,576 | 19.2 | 1,560 | 19.0 | 1,304 | 19.1 | 831 | 17.6 | 527 | 17.8 |
|                           | 329 | 2.4 | 188 | 2.3 | 180 | 2.2 | 112 | 1.6 | 64 | 1.4 | 36 | 1.2 |
| IADL                    | 854 | 6.1 | 451 | 5.5 | 317 | 3.9 | 169 | 2.5 | 111 | 2.4 | 61 | 2.1 |
| Depression symptoms     |     |     |     |     |     |     |     |     |     |     |     |     |
| Non-depressed (GDS <5)  | 7,056 | 50.6 | 4,501 | 54.7 | 5,046 | 61.6 | 4,624 | 67.6 | 3,299 | 70.0 | 2,195 | 74.2 |
| Depressed (GDS ≥5)      | 4,454 | 31.9 | 2,190 | 26.6 | 1,778 | 21.7 | 1,223 | 17.9 | 763 | 16.2 | 366 | 12.4 |
| Cognitive complaints    | 2,443 | 17.5 | 1,537 | 18.7 | 1,373 | 16.8 | 995 | 14.5 | 649 | 13.8 | 396 | 13.4 |
|                           |     |     |     |     |     |     |     |     |     |     |     |     |
| Relationship of Engagement in Leisure Activities to Mortality

Continued on next page.
active leisure activities and “other leisure activities” were associated with a lower risk of mortality ($P$ for linear trend $<0.001$), whereas there was no significant association between engagement in “cultural leisure activities” and lower mortality in the adjusted models ($P$ for linear trend $= 0.717$ in model 2, $0.827$ in model 3).

Another analysis, shown in Table 4, examined the association of the types and the number of leisure activities in terms of group...
Table 3. Association of the types and the number of leisure activities with all-cause mortality in older Japanese adults (n = 48,216), Japan, 2010–2016

| Type and the number of leisure activities | No. of deaths | Model 1a | Model 2b | Model 3c |
|-----------------------------------------|---------------|----------|----------|----------|
|                                         |               | HR   | 95% CI | P for trend | HR   | 95% CI | P for trend | HR   | 95% CI | P for trend |
| Physically-active leisure activities     |               |       |        |            |       |        |            |       |        |            |
| 0                                       | 3,168         | 1.00  | Referent | <0.001     | 1.00  | Referent | <0.001     | 1.00  | Referent | <0.001     |
| 1                                       | 1,403         | 0.80  | 0.75, 0.85 | 0.91 | 0.85, 0.97 | 0.91 | 0.85, 0.97 | 0.80 | 0.74, 0.86 | 0.80 | 0.74, 0.86 |
| 2–8                                     | 1,004         | 0.65  | 0.60, 0.70 | 0.80 | 0.74, 0.86 | 0.80 | 0.74, 0.86 | 0.80 | 0.74, 0.86 |
| Cultural leisure activities              |               |       |        |            |       |        |            |       |        |            |
| 0                                       | 3,931         | 1.00  | Referent | 0.026 | 0.717 | 0.827 |            |       |        |            |
| 1                                       | 1,099         | 0.93  | 0.86, 0.99 | 0.97 | 0.90, 1.04 | 0.97 | 0.90, 1.04 | 0.97 | 0.90, 1.04 | 0.97 | 0.90, 1.04 |
| 2–8                                     | 545           | 0.92  | 0.84, 1.01 | 0.99 | 0.90, 1.09 | 1.00 | 0.90, 1.10 | 1.00 | 0.90, 1.10 | 1.00 | 0.90, 1.10 |
| Other leisure activitiesd               |               |       |        |            |       |        |            |       |        |            |
| 0                                       | 3,663         | 1.00  | Referent | <0.001 | 1.00  | Referent | <0.001 | 1.00  | Referent | <0.001 |
| 1                                       | 1,401         | 0.86  | 0.81, 0.92 | 0.94 | 0.88, 1.00 | 0.94 | 0.88, 1.00 | 0.94 | 0.88, 1.00 | 0.94 | 0.88, 1.00 |
| 2–6                                     | 511           | 0.66  | 0.60, 0.73 | 0.75 | 0.68, 0.83 | 0.76 | 0.69, 0.84 | 0.76 | 0.69, 0.84 | 0.76 | 0.69, 0.84 |

CI, confidence interval; HR, hazard ratio.

aCox proportional hazards regression analysis; adjusted for sex, age, education, income, and employment status.
bCox proportional hazards regression analysis; additionally adjusted for living situation, marital status, smoking status, alcohol intake, body mass index, instrumental activities of daily living, depressive symptoms, cognitive complaints, self-rated health status, and chronic diseases (cancer, heart disease, stroke, diabetes mellitus, respiratory disease, and other diseases).
cCox proportional hazards regression analysis; additionally adjusted for frequency of meet friends, number of friends, emotional social support (received), and instrumental social support (received).
dIncludes exercise/Tai Chi, walking/jogging, tea ceremony/flower arrangement, photography, gardening, growing crops, traveling, hiking, and other.

Table 4. Association of the types and the number of leisure activities with all-cause mortality in older Japanese adults (n = 48,216), Japan, 2010–2016

| Type and the number of leisure activities | No. of deaths | Model 1a | Model 2b | Model 3c |
|-----------------------------------------|---------------|----------|----------|----------|
|                                         |               | HR   | 95% CI | P for trend | HR   | 95% CI | P for trend | HR   | 95% CI | P for trend |
| Group-based leisure activities          |               |       |        |            |       |        |            |       |        |            |
| 0                                       | 4,247         | 1.00  | Referent | <0.001     | 1.00  | Referent | <0.001     | 1.00  | Referent | <0.001     |
| 1                                       | 1,006         | 0.79  | 0.74, 0.85 | 0.87 | 0.81, 0.93 | 0.87 | 0.81, 0.94 | 0.85 | 0.75, 0.95 | 0.85 | 0.76, 0.96 |
| 2–5                                     | 322           | 0.73  | 0.65, 0.82 | 0.85 | 0.75, 0.95 | 0.85 | 0.76, 0.96 | 0.85 | 0.76, 0.96 | 0.85 | 0.76, 0.96 |
| Solitary leisure activities             |               |       |        |            |       |        |            |       |        |            |
| 0                                       | 3,836         | 1.00  | Referent | 0.006 | 0.259 | 0.326 |            |       |        |            |
| 1                                       | 1,212         | 0.93  | 0.87, 0.99 | 0.96 | 0.89, 1.02 | 0.96 | 0.90, 1.03 | 0.96 | 0.86, 1.05 | 0.96 | 0.87, 1.06 |
| 2–7                                     | 527           | 0.90  | 0.81, 0.99 | 0.95 | 0.86, 1.05 | 0.95 | 0.87, 1.06 | 0.95 | 0.87, 1.06 | 0.95 | 0.87, 1.06 |
| Othersd                                 |               |       |        |            |       |        |            |       |        |            |
| 0                                       | 2,882         | 1.00  | Referent | <0.001 | 1.00  | Referent | <0.001 | 1.00  | Referent | <0.001 |
| 1                                       | 1,420         | 0.85  | 0.80, 0.91 | 0.95 | 0.89, 1.02 | 0.95 | 0.89, 1.02 | 0.95 | 0.89, 1.02 | 0.95 | 0.89, 1.02 |
| 2–9                                     | 1,273         | 0.66  | 0.61, 0.70 | 0.82 | 0.76, 0.88 | 0.82 | 0.76, 0.88 | 0.82 | 0.76, 0.88 | 0.82 | 0.76, 0.88 |

CI, confidence interval; HR, hazard ratio.

aCox proportional hazards regression analysis; adjusted for sex, age, education, income, and employment status.
bCox proportional hazards regression analysis; additionally adjusted for living situation, marital status, smoking status, alcohol intake, body mass index, instrumental activities of daily living, depressive symptoms, cognitive complaints, self-rated health status, and chronic diseases (cancer, heart disease, stroke, diabetes mellitus, respiratory disease, and other diseases).
cCox proportional hazards regression analysis; additionally adjusted for frequency of meet friends, number of friends, emotional social support (received), and instrumental social support (received).
dIncludes exercise/Tai Chi, walking/jogging, tea ceremony/flower arrangement, photography, gardening, growing crops, traveling, hiking, and other.

Next, we repeated the analyses excluding the deaths occurring within the first one, two, and three years of follow-up in order to address reverse causality (ie, illness symptoms affecting engagement in leisure activity). The total number of leisure activities, “physically-active leisure activities,” and “group-based leisure activities” remained statistically significantly associated with reduced mortality hazard.

We conducted two sets of sensitivity analyses. With the former sensitivity analysis, we found that engagement in “sedentary leisure activities” was not associated with a reduced risk of mortality. After the second sensitivity analysis, it turned out that engagement in “non-physically-active solitary leisure activities” activity involvement (“group-based leisure activities,” “solitary leisure activities,” and “others”) with mortality. “Solitary leisure activities” were not associated with significantly lower mortality (P for linear trend = 0.006 in model 1, 0.259 in model 2, 0.326 in model 3), whereas “group-based leisure activities” showed a significant dose-response relationship with a lower risk of mortality (P for linear trend <0.001). “Others,” which are somewhere in between “group” and “solitary,” were partly associated with a significantly reduced mortality risk because engagement in two or more “others” turned out to lower the risk of all-cause mortality; HR 0.66 (95% CI, 0.61–0.70) in model 1, HR 0.82 (95% CI, 0.76–0.88) in model 2, HR 0.82 (95% CI, 0.76–0.88) in model 3. 0.88) in model 2, HR 0.82 (95% CI, 0.76–0.88) in model 2, HR 0.82 (95% CI, 0.76–0.88) in model 2, HR 0.82 (95% CI, 0.76–0.88) in model 2
was not associated with a significantly lower risk of mortality, which was in line with the two results above. Data of these sensitivity analyses are available from authors on request.

eTable 3 shows the association of each leisure activity with all-cause mortality (simultaneously mutually adjusted). Some activities such as golf, exercise/Tai Chi, dancing, and craft were independently associated with lower mortality, whereas others such as calligraphy, photography, gardening, and fishing were not.

**DISCUSSION**

In the present study, we assessed the association of engagement in leisure activities with all-cause mortality. We found a dose-response association between the total number of leisure activities and all-cause mortality, which is in line with the previous studies.5,7 One possible mechanism is related to psychological aspects of engagement in leisure activities. It has been reported that leisure participation contributes to higher subjective well-being,43 and in turn, subjective well-being is associated with a lower risk of mortality.45 But more plausibly, the larger the total number of leisure activities that individuals engage in, the higher the likelihood that they are engaged in effective activities for preventing death, such as “physically-active leisure activities” or “group-based leisure activities.”

We also found a dose-response association between engagement in “physically-active leisure activities” and lower all-cause mortality risk. Individuals who engage in a greater number of “physically-active leisure activities” will tend to be more physically active. The observed relationship could be explained by the dose-response protective association of physical activity with mortality which has been widely reported in many prior studies.46,47

Engagement in “group-based leisure activities” was similarly associated with a lower risk of mortality in a dose-response fashion. However, the pattern of decreasing mortality risk was not as clear as that seen in “physically-active leisure activities.” What mattered for lowering the risk of mortality appeared to be whether individuals are engaged in at least one group-based leisure activity or not; additional engagement did not lower the risk further. Previous studies have found that stronger social relationships are associated with a reduced risk of mortality,25 which could account for the correlation between “group-based leisure activities” and lower mortality.

In contrast, we did not find a significant association between engagement in “cultural leisure activities” and all-cause mortality. Partially, this is consistent with a previous study that suggested that making music and reading books or periodicals were not associated with a reduced risk of mortality.18 However, another study among Finnish employees, aged less than 65 years at the entry to the study, showed that reading and studying were associated with lowered mortality.19 The inconsistency may be explained by the difference in the study population. The present study investigated older Japanese adults, whereas the previous research focused on Finnish industrial employees.19 As our sensitivity analyses showed that engagement in “non-physically-active solitary leisure activities” was not associated with a lower risk of mortality, solitary cultural activities might have different associations with mortality depending on the current employment status. For the working generation, engaging with solitary cultural activities may be an indicator that they can afford to enjoy life and a high level of health consciousness. Working populations, who are enjoying solitary cultural activities, could be associated with their improved health behavior or health literacy, which might lead to a reduced risk of mortality.48

Besides, the present study showed that there was no significant association between participation in “solitary leisure activities” and all-cause mortality. In other words, engaging in solitary activities may have canceled some of the beneficial effects of participation in leisure activities. Loneliness, social isolation, and a low level of social engagement have been reported to be associated with increased mortality.23,49 Furthermore, the result is consistent with a previous study, which showed that increased frequency of exercise with other people was associated with better subjective health status among the elderly Japanese population.50

E-values were calculated to assess the robustness of the observed associations to unmeasured confounding. For example, as noted in eTable 2, the observed hazard ratio of 0.93 could be explained away by an unmeasured confounder that was associated with both the total number of leisure activities and mortality by a risk ratio of 1.35-fold each. Such potential unmeasured confounder may include physical environments,51 childhood socioeconomic status,45 or personality.52

Finally, our sensitivity analysis indicated that engagement in “sedentary leisure activities” was also not associated with all-cause mortality. This is inconsistent with the findings of the previous studies,12,14 in which sedentary behavior, measured as watching television, using computers, and sitting reading, showed a significant positive association with mortality. A possible explanation for the inconsistent results is that our sedentary leisure activities primarily involved cognitive or cultural activities, which are linked with beneficial health outcomes.1,15–20

There are some limitations to the present study. The first limitation concerns endogeneity. We cannot rule out reverse causation, even with longitudinal data. For example, more energetic individuals will tend to be engaged in a greater variety of leisure activities. Hence, the total number of leisure activities can be just a marker for vitality (which is a predictor of living longer). Second, we did not assess the intensity or frequency of engagement in leisure activities. Some people may report “walking/jogging” as their leisure activities, but they might do it only once a month. Third, we did not assess cause-specific mortality. Therefore, the mechanisms of how engagement in leisure activities reduces the risk of mortality are unclear. Fourth, our classifications of different leisure activities might be imprecise. For example, “playing musical instruments” and “fishing” are grouped under “solitary leisure activities,” but some people might always play musical instruments or go fishing with their friends. Finally, the generalizability of the results might be weak because the present analyses used data from participants who reported no disability in activities of daily living and responded to the questions regarding leisure activities and instrumental activities of daily living. The analytic samples were younger, had higher educational attainment, and had a higher income (eTable 4). Besides, according to the Cabinet Office of the Japanese Government, a nationally representative sample showed 11.1% of elderly males and 20.3% of elderly females lived alone in 2010,53 and among the analytic sample, 7.3% of males and 16.6% of females answered they lived alone.

In conclusion, we found that engagement in “physically-active leisure activities” and “group-based leisure activities” were
significantly associated with a lower risk of all-cause mortality among older Japanese adults. Further research in this field is needed considering the intensity/frequency of engagement, the causes of mortality, and other potential confounding factors, but our findings suggest that it might be helpful to encourage elderly people to engage in physically-active and social forms of leisure activities in order to promote healthy aging. We recommend that policymakers consider whether the intervention/implementation would improve physical activeness and in-person engagement among the community members.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.2188/jea.JE20200427.

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