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Effects of choir singing on physiological stress in Japanese older adults: its relationship with cognitive functioning and subjective well-being

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ABSTRACT

Background: Leisure activities are believed to contribute to healthy ageing. We compared the effects of choir singing and *go* playing on cortisol levels in Japanese older adults. We also examined its relevance to the older adults' emotional affect and cognitive performance.
Methods: Thirty-six older adults participated either in choir or *go* playing, within a 2 (groups)×2 (time points) design. Dependent measures included levels of salivary cortisol, as well as key psychological, cognitive, and neuropsychological measures.
Results: A significant two-way interaction was observed, showing that levels of salivary cortisol decreased for the choir but increased for the *go* groups. The decrease in salivary cortisol for the choir group correlated with the participant's negative affect and their degree of cognitive impairment.
Conclusion: Choir singing has the potential to reduce Japanese older adults' physiological stress. The decreases can be seen more prominently for people with stronger negative affect and cognitive impairment. Further research is required to replicate these effects.

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Ageing; choir singing; cortisol; cognitive function; subjective well-being

Introduction

The World Health Organization (2022) estimates that the world's population of people aged 60 years and older will double by 2050 (1.0 billion in 2020 and 2.1 billion in 2050). The ageing process is highly advanced in Japan, where the percentage of the population aged 65 or older was 28.9% in 2021 and is estimated to be 37.7% by 2050 (Statistics Japan, 2022). In this respect, the population of Japan can be viewed as that of the future, so that understanding health problems here can provide useful perspectives for the rest of the world.

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When considering health in older ages, stress management is an important issue, as physical and psychosocial stressors have a major influence upon mood, a sense of well-being, behaviour, and physical health (e.g. O'Connor et al., 2021). One pathway linking stress and health is the hypothalamic-pituitary-adrenal (HPA) axis, by which organisms adapt to physical and psychosocial changes in the environment (Burke et al., 2005). When humans experience stress, the HPA axis affects metabolic, cardiovascular, and central nervous systems, causing the release of cortisol from the adrenal cortex. Researchers have identified specific psychological factors that affect cortisol levels. For instance, the level of cortisol increases with negative affect (Burke et al., 2005) and cognitive tasks (Bohnen et al., 1990) but decreases with activities leading to relaxation (e.g. low-stress group singing, Bowling et al., 2022; Fancourt et al., 2015; Sakano et al., 2014; Taets et al., 2021).

Mental health has been assessed by the degree of perception of subjective well-being (Diener, 2006). The concept of subjective well-being refers to "an umbrella term for the different valuations people make regarding their lives, the events happening to them, their bodies and minds, and the circumstances in which they live" (Diener, 2006, p. 400). Generally, the concept is measured as an individual's experience of affective reactions and cognitive judgements of life satisfaction. Affective well-being comprises two independent sub-components, the presence of positive affect and the absence of negative affect (Mroczek & Kolarz, 1998; Nakahara, 2011). Life satisfaction represents a broad, reflective appraisal that a person makes of his or her life, through a report of how a person evaluates or appraises life taken as a whole (Diener et al., 1985).

When seeking to manage stress, the literature shows that enjoyable leisure activities are associated with psychosocial and physical measures relevant for health and well-being (Pressman et al., 2009; Yoshida et al., 2021; Zhang et al., 2021). People who take part in enjoyable activities exhibit lower blood pressure, cortisol levels, waist circumference, and body mass index. The psychological benefit is also robust, with higher levels of positive psychosocial states and lower levels of depression and negative affect (Pressman et al., 2009). Participation in leisure activities can improve social support of the older adults, whereby their mental health can be enhanced (Zhang et al., 2021). In the Japanese population, Yoshida et al. (2021) showed that mental health in older adults living alone is moderated by leisure activities. Enjoyable leisure activities, such as collaborating with friends in social contexts, can enrich older people's mental and physical health.

As a place and opportunity for social leisure activities, public community centres in Japan broadly provide many programmes. In the present study, we chose choir singing as a target activity, for the literature (e.g. Clift & Hancox, 2001) identified the perceived benefits of choir singing as greater well-being and relaxation, as well as enhanced breathing and posture, social interaction and engagement, spiritual growth and fulfilment, emotional expression, and cardiovascular and immune function. The impact of singing in choirs on the HPA axis has also been shown previously in psychoneuroendocrinology research (Fancourt et al., 2015, 2016), although some of studies have shown no effect (Kreutz et al., 2004). In general, young adults' levels of salivary cortisol are likely to decrease after choir singing with reduction of self-reported level of stress (Taets et al., 2021) and improvement of self-perceived emotional status and social connectedness (Bowling et al., 2022). The general purpose of the present study is to examine such psychophysiological effects of group singing for older people in Japan, who regularly join in choir activity.

We chose *go* playing as a control activity against choir singing, in light of its equivalent popularity in Japan. In *go*, two people sit face-to-face across a board, like chess. The purpose of *go* is to take a larger territory area by surrounding it with stones. Despite such simple rules, there are numerous ways to win the game, which demands that players have high working memory capacity and constructional and visuo-spatial function (Ouchi et al., 2005). Such cognitive demands may be one of the reasons why older adults in Japan favour it: Perhaps they see the game as providing anti-ageing, cognitive training.

What is still unknown is how stress regulation via choir or *go* activity interacts with older people's cognitive functioning and with their perception of subjective well-being. Choir singing facilitates positive well-being (Bowling et al., 2022; Clift & Hancox, 2001; Sakano et al., 2014; Taets et al., 2021), and the singers need high cognitive engagement to execute and coordinate performance parameters such as tempo, dynamics, and pitch. When playing *go*, the players also need much cognitive engagement to understand the current positions of stones as well as plan future strategies (Ouchi et al., 2005). By exploring how psychological and cognitive factors of older people contribute to the degree of stress regulation by these two activities, we can begin to assess which kinds of leisure pursuits are best suited for particular individuals to enhance their cognitive functioning and their mental health.

Purpose and hypothesis

In the present study, we explored the effects of two leisure activities (i.e. choir singing, *go* playing) on Japanese older adults' levels of acute stress, measured by salivary cortisol. We also explored what factors would be related to the increase (or decrease) of cortisol level by measuring their perceived subjective well-being as well as their cognitive capacities. We predicted that the level of cortisol would decrease with choir singing, in line with the literature (Bowling et al., 2022; Fancourt et al., 2015, 2016; Sakano et al., 2014; Taets et al., 2021), whereas such effects would not be shown in *go* playing (no effects or increase with *go* playing). As for the relationship between the salivary cortisol and cognitive and affective states, the literature in group singing has not shown any significant correlation between levels of hormone and affective status (Bowling et al., 2022). However, according to a systematic review (Ouanes & Popp, 2019), elevated cortisol levels may exert detrimental effects on cognition in patients with Alzheimer's disease, so that, possibly, older people with lower baselines of cognitive functioning might be influenced more by doing the leisure activities.

Method

Design

The study was conducted in a 2 (type of activity: choir versus *go*; between-subjects) × 2 (time: pre-activity versus post-activity; within-subjects) mixed design. We assessed the participant's level of salivary cortisol as a dependent variable. In this study, participants were older adults who join in either *go* or choir club, so there was no randomisation to conditions.

Participants

To determine an appropriate sample size, we conducted power analysis using G*Power 3.1.9.2 (Faul et al., 2007) to detect "medium" effect ($f = 0.25$, Cohen, 1988) in the setting of $\alpha = .05$and $\beta = .80$, showing that a total sample size $N = 34$ would be needed (i.e. $n = 17$ for each group). We recruited participants at a community centre in Japan where people regularly join in either choir or *go* activities at least two times per month. Though there are multiple *go* clubs at the community centre, the expected number of participants in either of the clubs were less than 17, so that participants from two different *go* clubs were recruited. As for the choir, we recruited participants from a single club. For both groups, we recruited members who were 65 years old or more and voluntarily wanted to participate in our study. Twenty-eight people (24 men, 4 women, 65–89 years old, $M = 78.61$, $SD = 6.81$) from the *go* clubs and 21 people (3 men, 18 women, 67–85 years old, $M = 77.48$, $SD = 5.14$) from the choir took part.

Exclusion criteria

Our target participants in the present study were healthy older adults. We excluded 4 participants (3 from the *go* and 1 from the choir groups) in the analysis because their score of the Mini Mental States Examination (MMSE, Folstein et al., 1975) was lower than the cut-off score of 24 (23 or less), indicating high possibility of dementia. Another 9 participants were also excluded because of failing measurements of saliva samples ($n = 4$) or missing responses to the questionnaires ($n = 5$). Thirty-six participants (17 for the choir and 19 for the *go* groups) remained for the analyses.

Physiological and psychological measures

We collected physiological and psychological measures for which the reliability and validity have been confirmed: salivary cortisol (physiological stress), positive and negative affect and satisfaction with life (subjective well-being), Stroop and reverse-Stroop interference scores (selective attention), MMSE (overall degree of cognitive impairment), the Trail Making Test part A (TMT-A, Reitan, 1958), and the Mie Constructional Apraxia Scale (MCAS, Satoh et al., 2016). The details were described below.

Saliva was collected via a passive drool method facilitated by polypropylene straws into the 1.5 mL Salivetts (Eppendorf, UK). Assessment of cortisol in saliva has proven a valid and reliable reflection of the respective unbound hormone in blood and is widely accepted and frequently employed in psychoneuroendocrinology research (Kirschbaum & Hellhammer, 1994). Collection of saliva was more stress-free than that of blood and easy to perform by non-clinicians. The saliva samples were shipped within three days of their collection to the Kirschbaum laboratory in Germany (Dresden LabService GmbH), where assays for the neuroendocrine stress hormone cortisol were carried out. The measure was reported in nmol/L and in the following analyses we used the base-10 logarithmic values for the data to be normally distributed.

Participants were asked to answer questionnaires, by which we measured the socio-demographic characteristics and the perception of subjective well-being. The perception of subjective well-being was assessed with two questionnaires: the Satisfaction with Life Scale (Diener et al., 1985) translated by Oishi (Oishi, 2009,

p. 5 items) and the Affective Well-being Scale (Nakahara, 2011, p. 7 items). The Satisfaction with Life Scale is a 5-item instrument with a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7). Nakahara's Affective Well-being Scale is the Japanese translation of the Positive and Negative Affect Scale (Mroczek & Kolarz, 1998). The scale can assess both positive and negative affects during the past 30 days, using a 5-point Likert scale from "none of the time (1)" to "all of the time (5)."

To measure the participant's selective attention, we conducted the Stroop colour-word test in a Japanese form, customised for group testing (Hakoda & Watanabe, 2005). We computed two measures: Stroop interference and reverse-Stroop interference scores (Hakoda & Watanabe, 2005; Matsumoto et al., 2012; Song & Hakoda, 2015). The Stroop interference score is a ratio of the number of correct responses of naming the ink colour of an incongruent colour-word combination (e.g. the word "green" printed in red ink) to that of naming the ink colour of a colour patch. The reverse-Stroop interference score is a ratio of the number of correct responses of reading the incongruent colour-word combination to that of reading the black-coloured word.

The MMSE is a short screening tool for providing an overall measure of cognitive impairment, scored from 0 (high impairment) to 30 (no impairment). In the TMT-A, the participants quickly drew lines on a page connecting 25 consecutive numbers, for which the time was used as a measure of motor speed and visual attention. In the MCAS, each participant drew a Necker cube, which was videotaped. Based on the drawing process of each participant, the degree of constructional apraxia (CA) was scored from 0 (no possibility of CA) to 6 (high possibility of CA) as a guideline (Satoh et al., 2016).

Procedure

The activity of one *go* club started at 10:00 and those of the other *go* and the choir clubs started at 13:00 and 13:30, respectively. Before testing, the group members were gathered in one room and informed of the purpose and the detailed procedure of testing. First, saliva was collected to examine "pre-activity" cortisol. Then, participants performed the Stroop colour-word test. After the Stroop test was completed, they joined in their own activities for approximately 90 minutes, as they do regularly. After the activity was finished, saliva was collected again to examine "post-activity" cortisol. After the saliva collection, three types of neuropsychological tests were conducted for each participant in a face-to-face condition: the MMSE, the TMT-A, and the MCAS. The total duration of the experiment was about 100 to 150 minutes including about 35-minutes testing (20 minutes for the pre-activity testing, 1–2 hours for the leisure activity, and 20 minutes for the post-activity testing).

This work was conducted in accordance with the principles of the declaration of Helsinki, and approved by the Medical Research Ethics Committee involving Living Human Participants at Ritsumeikan University (Approval Number: BKC-2016-015). The aim of the study, the method, the protection policy of personal data, and the withdrawal policy were informed both in spoken and written communication. Written consent was obtained from all participants.

Statistical analyses

First, we conducted Shapiro-Wilk tests to examine whether the data was normally distributed. For the data that was normally distributed, we conducted a parametric test (i.e. analysis of variance), but otherwise nonparametric tests were applied (i.e. Spearman's correlation analyses). We examined how the level of salivary cortisol would differ between pre- and post-activities across the choir and the *go* groups by two-way mixed-design analysis of variance. We then computed Spearman's correlation coefficients to explore how the increase (or the decrease) level of cortisol was related to the participants' perception of subjective well-being and cognitive functioning (i.e. Stroop test, MMSE, TMT-A, MCAS). These data analyses were performed using R 3.4.1.

Results

Before main analyses, we confirmed that the level of salivary cortisol did not differ significantly between the two *go* clubs (i.e. one starting 10 am and the other starting 13 pm) by independent *t*-tests, $t_{(17)} = 0.18$, $p = .86$, $d = 0.08$ (pre-activity), $t_{(16)} = 0.67$, $p = .51$, $d = 0.31$ (post-activity). We pooled data in the following analyses, though we acknowledge that cortisol levels generally tend to decrease within a day (Edwards et al., 2001).

Effects of activities on the level of salivary cortisol

For the choir and the *go* groups, we computed the mean level of salivary cortisol (Figure 1). According to Figure 1, the level of salivary cortisol (in base-10 logarithmic value) appeared to increase by *go* activity (pre-activity: $M = 0.73$, $SD = 0.30$; post-activity: $M = 0.87$, $SD = 0.40$) but decrease by choir singing (pre-activity: $M = 0.60$, $SD = 0.22$; post-activity: $M = 0.47$, $SD = 0.32$). To confirm this, we conducted a two-way analysis of variance with the type of activity (choir versus *go*) as the between-subjects factor and time (pre versus post) as a within-subjects factor. The test showed a significant main effect of type of activity and a significant two-way interaction, $F_{(1,34)} = 7.42$, $p = .01$, $\eta_G^2 = .13$ (type of activity), $F_{(1,34)} = 8.87$, $p = .005$, $\eta_G^2 = .05$ (two-way interaction). The main effect of time was not significant, $F_{(1,34)} = 0.03$, $p = .88$, $\eta_G^2 < .001$. For the significant interaction, we conducted post-hoc *t*-tests using Shaffer's modified sequentially rejective Bonferroni procedure. The difference between the choir and the *go* groups was not significant at the pre-activity ($p = .16$), but it was significant at the post-activity ($p = .003$). The differences between the pre- and the post-activities were significant for the *go* group ($p = .04$, $\eta_G^2 = .04$) and approaching significance for the choir group ($p = .06$, $\eta_G^2 = .05$), revealing a contrasting influence of the two leisure activities on participants' cortisol levels. In our hypothesis, we predicted that the level of cortisol would decrease with choir singing whereas such effects would not be shown in *go* playing (no effects or increase with *go* playing). This hypothesis was overall accepted in that there was a trend of decrease in cortisol with choir singing whereas the level of cortisol increased with *go* activity.

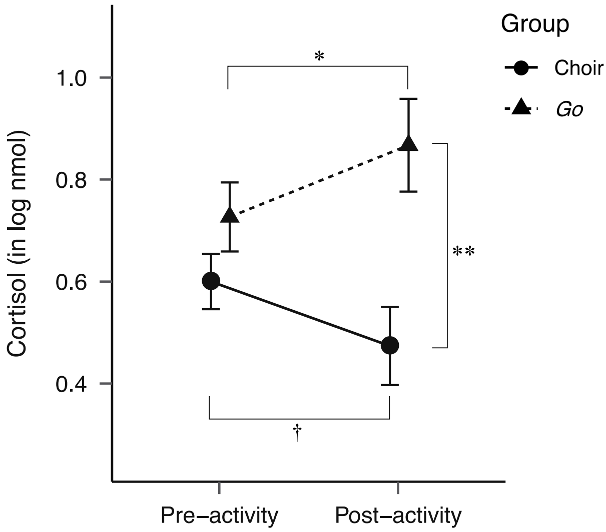

Figure 1. Mean values for the effects of type of activity and time point on the salivary cortisol. The base 10 logarithms were shown. Error bars indicate standard errors. $^{**}p < .01$, $^{*}p < .05$, $^{\dagger}p < .10$.

Correlation among the level of salivary cortisol, subjective well-being and cognitive measures

Next, we examined how the changes of salivary cortisol would correlate with the older adults' traits of subjective well-being and cognitive abilities. First, the statistical properties of psychological and cognitive measures were checked. Table 1 shows the descriptive statistics of the measures, and the differences between the groups were tested by Mann-Whitney's *U* tests, because Shapiro-Wilk tests showed the deviation from the normal distribution in each score of the positive affect, the negative affect, the satisfaction with life, the MMSE, and the MCAS (*ps* < .05). Mann-Whitney's *U* tests showed no significant differences between the groups for 8 out of 9 measures (*ps* > .05); Only for the Stroop interference score, the *go* group scored significantly better than the choir group ($p = .03$).

Based on the aforementioned non-normal distribution of the data, we also computed Spearman's correlation coefficients with the difference (post – pre) of the level of cortisol (the right columns in Table 1; See Appendix A for correlation coefficients among all measures). For the choir group, the difference level of cortisol correlated positively with the MMSE, and negatively with the negative affect and the Stoop interference score. No significant correlation coefficients were shown in the *go* group. This indicates that the level of cortisol decreased with choir singing more for people with the lower cognitive functioning (lower score of the MMSE and higher Stroop interference) and with stronger negative affect.

Discussion

In the present study, we investigated the effect of choir singing versus *go* playing on older adults' physiological stress levels, as measured by salivary cortisol. Results showed a contrasting effect between the two: There was a trend of decrease in cortisol with choir singing whereas the level of cortisol increased with *go*. Mean salivary cortisol of our

Table 1. Mean and standard deviations of the subjective well-being (a) the neuropsychological assessment (b) and the Stroop interference (c) for each of the choir and the go groups. Results of Mann-Whitney's U tests for the differences between the groups were shown in the middle columns. Spearman's correlation coefficients between each measure and the pre-post difference of the cortisol level were shown in the right columns.

	M (*SD*)						Spearman's correlation			
	Choir		*Go*		*U* test		Choir		*Go*	
	(n = 17)		(n = 19)		*U*	*p*	r_s	*p*	r_s	*p*
(a) Subjective Well-being										
Positive Affect	3.67	(0.90)	3.32	(0.92)	114.50	.13	.16	.55	.30	.21
Negative Affect	1.60	(0.63)	1.51	(0.43)	158.00	.91	-.53*	.03	-.06	.81
Satisfaction with Life	4.27	(1.24)	4.78	(1.26)	194.00	.31	.14	.59	-.05	.84
(b) Neuropsychological Assessment										
MMSE	28.06	(2.30)	27.53	(2.27)	136.50	.43	.77***	< .001	.12	.64
TMT-A (s)	111.88	(27.52)	108.58	(40.41)	140.00	.51	-.07	.79	.14	.57
MCAS	3.18	(1.55)	3.79	(1.47)	200.00	.22	.11	.67	.01	.96
(c) Scores of Stroop Test										
Interference	30.80	(16.41)	19.30	(15.11)	95.50*	.04	-.64**	.01	-.23	.34
Reverse Interference	-6.63	(13.81)	-1.88	(8.61)	190.00	.37	-.10	.71	-.32	.18

***$p < .001$, **$p < .01$, *$p < .05$.

participants at the baseline (pre-activity) was 6.68 nmol/L (*go* group) and 4.60 nmol/L (choir group), which are equivalent to those in Peeters et al. (2003, Figure 1) showing mean concentration of salivary cortisol of 4–8 nmol/L at 9:45 am to 2:15 pm. In Peeters et al. (2003), extreme cortisol concentrations were assumed to be those greater than 44 nmol/L, so that salivary cortisol of our participants, ranged from 0.7 to 24.99 nmol/L, can be considered within normal levels. Furthermore, according to our analysis, the decrease level of cortisol by choir singing correlated with the participants' cognitive performance and subjective well-being. This suggests that the physiological stress decreases with choir singing more for older adults with lower levels of cognitive functioning and higher levels of negative affect.

Cortisol levels were likely to decrease with choir singing as a whole. The finding is in line with the literature showing similar reduction with older non-musicians singing for only 4-minutes (Sakano et al., 2014), young adults (Bowling et al., 2022; Taets et al., 2021), professional singers (aged in their 30s and 40s) performing under low-stress conditions (Fancourt et al., 2015), and cancer patients and their carers singing in cancer choirs (Fancourt et al., 2016). Moreover, the literature shows that choir singing temporally decreases both physiological (e.g. biomarkers in saliva) and psychological types of stress (e.g. Bowling et al., 2022; Fancourt et al., 2015, 2016; Sakano et al., 2014; Taets et al., 2021), but the evidence of correlation between these two temporal types of measures have rarely been shown, as in Kreutz et al. (2004). In the present study, the older adult's baseline of negative affect, which was asked as "affective states of past 30 days," correlated with the decreasing level of salivary cortisol among the choir members. This suggests that physiological stress by choir singing can be decreased more for older adults with stronger negative affect.

We also showed that the decreasing level of cortisol by choir singing correlated with lower cognitive functioning, measured by the MMSE and the Stroop interference score. A Stroop interference score indicates the degree of language processing against color processing, showing abilities of selective attention and inhibitory function. An fMRI study (Song & Hakoda, 2015) showed that a Stroop interference score primarily involves, independent of a reverse-Stroop interference score, the activation of the middle frontal gyrus (BA9) in the brain. The area is involved in the human's pitch control of vocalisation based on auditory feedback (Toyomura et al., 2007). Choir members with higher degree of impairment in this region probably tend to reduce cognitive endeavour to manipulate multiple performance parameters (including pitch) with other members. This is speculation at present, but such constrained cognitive abilities may be relevant to the decrease release of cortisol, which should be examined by incorporating brain scanning in a future study. Nevertheless, the benefit of choir singing for physiological stress can be given more in older adults with lower degree of cognitive functioning.

We showed that salivary cortisol increased with *go* activity, which was chosen as a control group against the choir. The finding may be related to the fact that cortisol levels increase with cognitive tasks, such as mental arithmetic and working memory tasks (Bohnen et al., 1990). *Go* playing demands much of players' cognitive resources, which may in turn increase levels of cortisol. Despite such demands of cognitive resources, we did not find any correlation between the physiological and the psychological measures in the *go* group. In other words, *go* playing overall increases the players' cortisol, regardless of their "baseline" levels of cognitive and psychological measures. *Go* playing is a one-on-one match and the player enjoys not only such a competitive situation but also communication with the partner player, which differs from arithmetic and working memory tasks. As multifaceted factors are relevant to leisure activities, the other activities in community centres should be incorporated in the future study to know the mechanism of the interrelationships among physiological stress, subjective well-being, and cognitive impairments of older adults.

In conclusion, we have demonstrated a contrasting effect of choir versus *go* activities on older adults' physiological stress levels: The level of salivary cortisol is likely to decrease with choir singing whereas increases with *go* playing. We also identified that the benefits choir singing to reduce the physiological stress are exhibited more for people with higher negative affect and lower ability of selective attention. One weakness of the present study is that a control group, even with no leisure activities, should have been recruited. Also, though the sample size was determined based on the power analysis, the significance levels of our test within the separate groups are close to $p = .05$, indicating that a larger sample should be incorporated in future study. Due to the nature of this study, our self-selected participants have fully experienced either choir singing or *go* playing, so that, possibly, the outcomes of this study might be different for people who are not accustomed to these activities. The temporal and longitudinal effects of these leisure activities should be explored in another study. Further work should also identify the effects of other cognitive (e.g. computer game, *haiku*, language learning), artistic (e.g. painting, knitting, flower arrangement), and physical activities (e.g. exercise, walking, dance, yoga) on such older people's regulation of physiological stress, especially considering "social" factors (i.e. doing alone versus doing with others). By doing so, we will understand how different aspects of leisure activities impact on older people's physiological stress, such as social involvement, cognitive effort, and physical exertion. In this study, we showed that two types of cultural social practises (i.e. choir, *go*) can be both beneficial to keep older people's physiological and psychological health. Providing places to give such recreational opportunities for older adults (like community centres in Japan) will be important to reduce their loneliness and to enhance their subjective and psychological well-being (Yoshida et al., 2021). Whether the outcomes of the present study are applicable to other countries where cultural contexts, personality, environment, social welfare, and so forth, are different from those in Japan should await another study. Bearing in mind the speed of ageing all over the world, cross-cultural studies of health-oriented activities are needed to identify the generalisability and potential applications of the present study.

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Appendix A

Spearman's correlation coefficients among measures for each group.

Measures	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Choir Group (*n* = 17)										
(A) Pre-activity Cortisol (in log nmol)	1.00									
(B) Post-activity Cortisol (in log nmol)	.63**	1.00								
(C) Positive Affect	-.13	.15	1.00							
(D) Negative Affect	.61**	.07	-.39	1.00						
(E) Satisfaction with Life	.09	.10	-.10	-.09	1.00					
(F) MMSE	-.03	.53*	.06	-.56*	.04	1.00				
(G) TMT-A	.00	-.13	-.36	.23	.17	-.21	1.00			
(H) MCAS	.34	.28	.12	.27	-.14	.01	-.17	1.00		
(I) Stroop Interference	.11	-.32	-.20	.46	-.31	-.52*	.32	.19	1.00	
(J) Stroop Reverse Interference	.03	-.16	-.08	.18	.51*	-.18	.22	.24	.03	1.00
***Go* Group (*n* = 19)**										
(A) Pre-activity Cortisol (in log nmol)	1.00									
(B) Post-activity Cortisol (in log nmol)	.63**	1.00								
(C) Positive Affect	.01	.24	1.00							
(D) Negative Affect	.17	.01	-.14	1.00						
(E) Satisfaction with Life	-.06	.03	.54*	-.10	1.00					
(F) MMSE	.10	.29	.41	-.18	.51	1.00				
(G) TMT-A	.28	.35	-.13	.18	.10	-.03	1.00			
(H) MCAS	-.15	-.10	-.16	.34	-.20	.04	.11	1.00		
(I) Stroop Interference	.21	-.04	.00	-.19	.10	.05	-.01	-.69**	1.00	
(J) Stroop Reverse Interference	-.13	-.26	.12	-.05	.48*	.14	-.17	-.47*	.33	1.00

**$p < .01$, *$p < .05$.