体力研究 BULLETIN OF THE PHYSICAL FITNESS RESEARCH INSTITUTE
No.115 pp.35～41 Apr., 2017

【Brief Communication】

The effect of an acute bout of slow aerobic dance on mood and executive function in older adults: a pilot study

Kazuki Hyodo[1), Kazuya Suwabe[2), Hideaki Soya[3),
and Toshiya Nagamatsu[1)

Key words: aging, rhythmic exercise, two-dimensional mood scale, Stroop task, functional near infrared spectroscopy.

Introduction

In older age, regular physical activity plays a crucial role in the maintenance of cognitive function. Previous studies have demonstrated that aerobic fitness attenuates age-related decreases in tissue density throughout the brain and in the prefrontal cortex (PFC) in particular— the area primarily responsible for the control of executive function and mood regulation[4,5)].

Recently, we observed that 10 minutes of low-intensity cycle exercise improved executive task performance via task-related increases in prefrontal activation, and that this effect was modulated by changes in the level of psychological arousal in young adults[3)]. Since previous study found that low-intensity exercise intervention prevented age-related atrophy of the PFC and improved cognitive function in older adults[10)], similar improvements in executive function may occur in older adults following participation in an acute bout of low-intensity exercise.

To apply our findings and hypothesis to real-life situations for older adults, we focused on the effect of light rhythmic exercises, as these are the most familiar and easiest to perform for older adults. Recently, in collaboration with the Japan Aerobic Federation, we developed a novel light rhythmic exercise protocol called "slow aerobic dance." This exercise program consists mainly of dynamic upper body stretching (e.g., trunk rotation), performed to slow-tempo music. In the present study, we aimed to clarify the effect of an acute bout of slow aerobic dance on mood and executive function in older adults, relative to low intensity cycle exercise at the same tempo.

Methods

A. Participants

Thirteen older adults (65-74 years old, 6 women) participated in the current study. All participants were right-handed native Japanese-speakers. All participants were cognitively healthy (screened using the Mini-Mental State Examination, score greater than 23) and free of psychiatric disorders (screened using the Geriatric Depression Scale, score less than 10), and had normal or corrected-to-normal vision. Written informed consent was obtained from all participants prior to participation. This study was approved by the Ethical Review Committee of the Meiji Yasuda Life Foundation of Health and Welfare (Approval number: 28003). Patient characteristics are presented in Table 1.

1) Physical Fitness Research Institute, Meiji Yasuda Life Foundation of Health and Welfare, Tokyo, Japan.
2) Graduate School of Comprehensive Human Science, Doctoral Program in Health and Sport Science, University of Tsukuba, Ibaraki, Japan.
3) Laboratory of Exercise Biochemistry and Neuroendocrinology, Department of Sports Neuroscience, Advanced Research Initiative for Human High Performance (ARIHHP), Faculty of Health and Sport Sciences, University of Tsukuba, Ibaraki, Japan.

B. Experimental procedure

The present study consisted of three experimental conditions conducted on separate days: resting control (CTL), cycle ergometer exercise (ERGO), and slow aerobic dance (AERO) (Figure 1A). In the ERGO and AERO conditions, participants performed the Stroop task before and 5 min after 10 minutes of cycle exercise at an intensity of 50% ventilatory threshold (VT) on an upright cycle ergometer (Corival cpet, Lode, Netherlands) (ERGO) or slow aerobic dance (AERO). Participants also completed the Two-Dimensional Mood Scale (TDMS) before the pre-Stroop session and after exercise. Both exercise conditions were performed to the same music at 90 bpm (= 45 rpm for cycle exercise). The music was composed by the Japan Aerobic Federation ("March for Tomorrow"; 90 bpm; https://www.aerobic.or.jp/slowaerobic/document/mp3/letstryagain90.mp3). Heart rate (HR) was measured during both exercise sessions, and Borg ratings of perceived exertion

Table 1. Demographic data.

	Male		Female	
n = 13 (Male = 7, Female = 6)	Mean	SD	Mean	SD
Age (years)	69.3	2.8	69.7	2.7
Height (cm)	163.6	4.0	150.8	6.4
Weight (kg)	61.0	5.2	52.1	5.8
Education (years)	14.9	2.0	12.7	1.6
MMSE (score)	27.3	2.2	28.0	2.0
GDS (score)	2.3	1.8	2.5	1.6
VT (ml/kg/min)	14.4	2.7	11.8	1.3
Workload of 50%VT (watt)	32.7	7.2	23.8	3.1

MMSE = Mini-Mental State Examination, GDS = Geriatric Depression Scale, VT = ventilatory threshold.

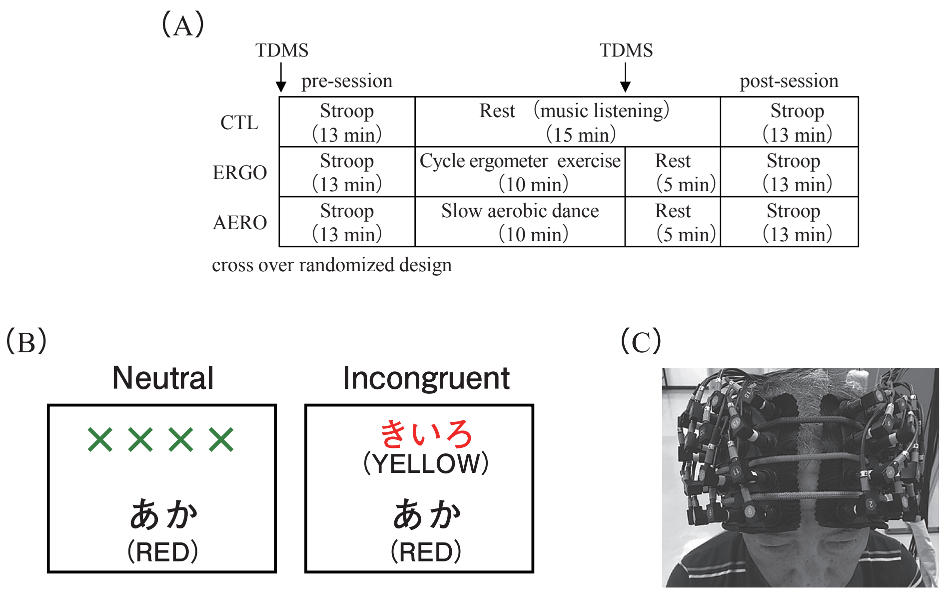

Figure 1. Experimental design.
(A) Procedures of control (CTL), cycle ergometer exercise (ERGO), and slow aerobic dance (AERO) conditions. (B) Stroop task presentation. Examples of neutral and incongruent trials of color-word matching Stroop task are illustrated. (C) Position of fNIRS probes.

(RPE) were evaluated at the end of each session. In the CTL condition, participants sat in a chair and rested during the interval between pre- and post-Stroop sessions instead of performing exercise. During the resting state in the CTL condition, participants listened to the same music used in the exercise sessions for the first 10 minutes and completed the TDMS.

Prior to the experimental days, participants were brought to the laboratory and performed graded exercise tests on the cycle ergometer to determine their own VT. Participants also practiced the slow aerobic dance once and Stroop task twice to familiarize themselves with the exercise conditions and cognitive tasks.

C. Slow aerobic dance

The slow aerobic dance protocol consisted of three basic movements: A) pull elbow back, B) twist upper body, C) swing arm and bend body to the side (Figure 2). Participants repeated each movement of the routine and slightly more complex motions based on these basic movements while watching a 10-minute tutorial

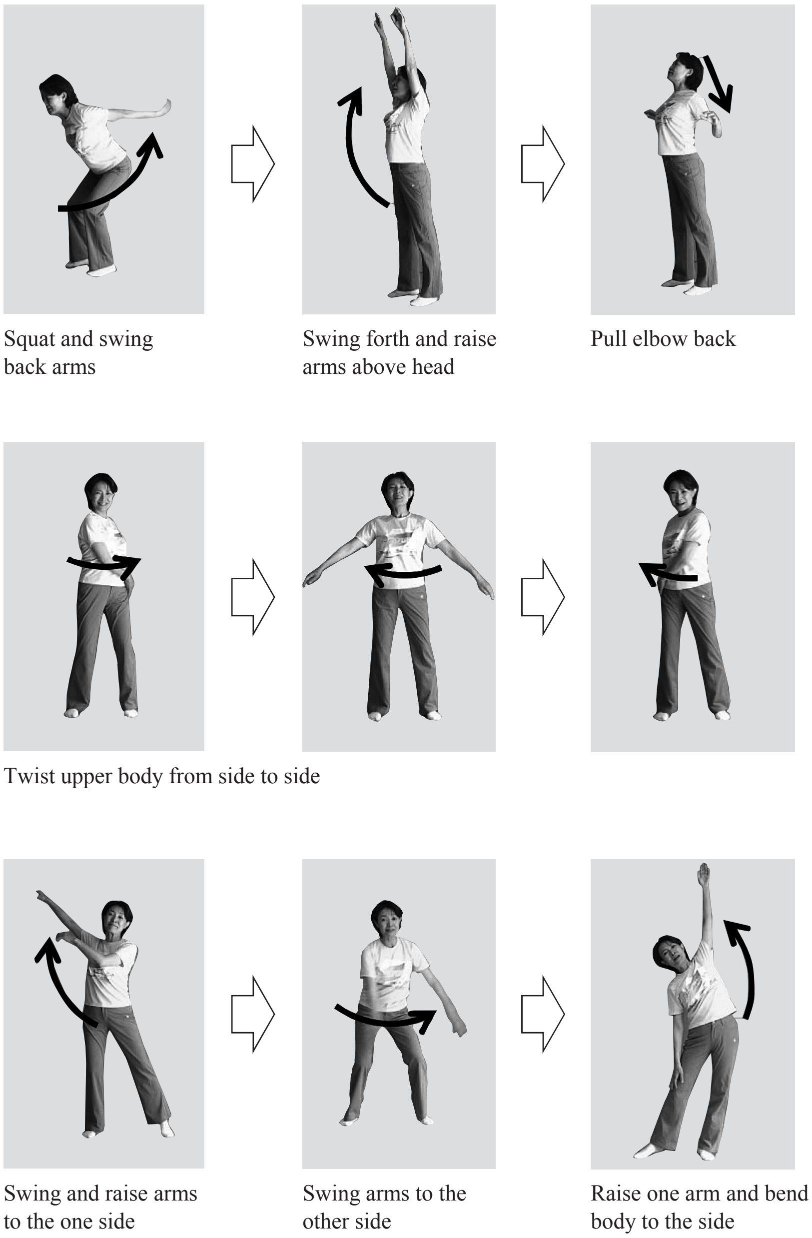

Figure 2. Illustration of the three basic components of the slow aerobic dance routine.

video.

D. Mood

To evaluate psychological mood states, we used the TDMS[9] to evaluate levels of pleasure, arousal, vitality, and stability.

E. Executive function

We adopted the computer-based color-word matching Stroop task[7]. The task consisted of 30 neutral and 30 incongruent trials presented in random order (Figure 1B). Stroop interference time (difference in correct reaction time between incongruent and neutral trials) was used as the index of executive function[7].

F. Functional near-infrared spectroscopy (fNIRS)

We monitored prefrontal activation during the Stroop task via multichannel fNIRS (FOIRE3000, Shimadzu Corporation, Japan). As in previous studies[6], fNIRS probes were set to cover lateral PFC activation foci (Figure 1C), and neighboring channels were combined for the dorsolateral PFC (DLPFC), ventrolateral PFC (VLPFC), and frontopolar area (FPA) in each hemisphere using virtual registration[11]. The difference in task-related oxy-hemoglobin (oxy-Hb) signal change between incongruent and neutral trials was calculated as the level of Stroop-interference-related brain activation.

G. Statistical analyses

TDMS scores, Stroop task performance, and fNIRS data were analyzed via repeated measures two-way ANOVA with condition (CTL/ERGO/AERO) and time (pre/post) as factors. When significant main effects or interactions were observed, *post hoc* analysis of the simple main effects or degree of change (post – pre) was performed, with Bonferroni correction. Statistical analyses were performed using SPSS version 24 (SPSS, Inc., USA). The significance level was set to $P < 0.05$ for all analyses.

Results

A. Exercise intensity

HR changes from baseline following cycle exercise and slow aerobic dance were 15.6 ± 7.4 bpm (from 64.9 ± 6.2 to 80.8 ± 9.7) and 17.0 ± 6.3 bpm (from 68.6 ± 8.9 to 86.0 ± 12.4), respectively. RPE at the end of the cycle exercise and slow aerobic dance sessions were 11.4 ± 1.5 and 11.1 ± 1.3 points, respectively. These results indicated that exercise intensity in both conditions was within the range of very light to light intensity, in accordance with American College of Sports Medicine (ACSM) guidelines[1]. Moreover, we observed no significant difference in HR change and RPE between the exercise conditions, suggesting that the intensity of both conditions was comparable.

B. Mood

Table 2 includes data regarding TDMS scores, Stroop task performance, and fNIRS measurements.

We observed significant interaction effects between time and condition with regard to vitality ($f(12,2) = 5.868$, $P < 0.01$), stability ($f(12,2) = 4.708$, $P < 0.05$), and pleasure levels ($f(12,2) = 8.468$, $P < 0.01$), as calculated based on TDMS scores. *Post hoc* analyses revealed that the change in vitality for the AERO condition was greater than that for the ERGO condition ($t(12)=3.51$, $P < 0.05$, Bonferroni corrected), that the change in stability for the CTL condition was greater than that in ERGO condition ($t(12)=3.70$, $P < 0.05$, Bonferroni corrected), and that the change in pleasure level was greater for the AERO and CTL conditions than for the ERGO condition ($t(12)=3.57$, $P < 0.05$, Bonferroni corrected). No significant interactions or main effects were observed with regard to arousal level.

C. Stroop task

No significant interactions or main effects were observed with regard to Stroop interference time (Table 2).

D. fNIRS data

No significant interactions or main effects were observed with regard to Stroop-interference-related oxy-Hb change for any region (Table 2).

Table 2. Changes in each variable between the pre- and post-exercise conditions.

		Pre-exercise	Post-exercise	post – pre
		Mean (SD)	Mean (SD)	Mean (SD)
Two-Dimensional Mood Scale				
Arousal (points)	CTL	−3.2 (4.9)	−3.6 (5.2)	−0.4 (4.1)
	ERGO	−1.5 (2.1)	−0.6 (2.0)	0.9 (3.2)
	AERO	−1.2 (2.9)	−0.1 (2.3)	1.2 (3.0)
Pleasure (points)	CTL	8.8 (6.5)	10.2 (6.0)	1.5 (5.3) †
	ERGO	10.9 (5.1)	8.3 (5.3)	−2.6 (3.5)
	AERO	9.8 (5.3)	13.5 (4.0)	3.6 (5.5) †
Vitality (points)	CTL	2.8 (5.1)	3.3 (4.7)	0.5 (4.2)
	ERGO	4.7 (2.8)	3.8 (2.8)	−0.8 (2.2)
	AERO	4.3 (3.0)	6.7 (2.5)	2.4 (2.7) †
Stability (points)	CTL	6.0 (2.6)	6.9 (3.1)	0.9 (2.1) †
	ERGO	6.2 (2.7)	4.5 (2.9)	−1.8 (2.6)
	AERO	5.5 (3.0)	6.8 (2.2)	1.2 (3.5)
Executive function				
Stroop interference time (msec)	CTL	288.2 (123.6)	257.0 (137.1)	−31.2 (102.2)
	ERGO	279.7 (102.4)	258.5 (132.5)	−21.2 (76.6)
	AERO	294.9 (128.7)	272.0 (130.1)	−22.8 (96.8)
fNIRS data (μm・MM)				
Left DLPFC	CTL	0.55 (0.73)	0.22 (1.10)	−0.34 (1.24)
	ERGO	0.64 (0.91)	0.20 (1.13)	−0.44 (1.68)
	AERO	0.19 (0.85)	0.20 (0.74)	0.01 (0.88)
Left VLPFC	CTL	0.70 (1.25)	0.81 (1.76)	0.11 (1.81)
	ERGO	1.30 (1.82)	0.75 (1.16)	−0.55 (2.62)
	AERO	1.09 (1.23)	0.66 (1.16)	−0.43 (1.35)
Left FPA	CTL	1.12 (1.51)	0.93 (1.58)	−0.19 (1.85)
	ERGO	1.39 (1.20)	0.92 (1.36)	−0.48 (2.16)
	AERO	0.74 (1.39)	0.48 (1.70)	−0.26 (1.39)
Right DLPFC	CTL	0.55 (0.76)	0.35 (1.10)	−0.21 (1.30)
	ERGO	0.68 (0.77)	0.23 (1.41)	−0.45 (1.46)
	AERO	0.21 (0.99)	0.32 (0.90)	0.12 (0.82)
Right VLPFC	CTL	1.08 (1.02)	0.90 (1.60)	−0.18 (1.16)
	ERGO	1.43 (1.12)	1.05 (1.44)	−0.38 (1.99)
	AERO	0.74 (1.34)	0.42 (0.93)	−0.32 (1.40)
Right FPA	CTL	0.89 (1.18)	0.79 (1.57)	−0.10 (1.06)
	ERGO	1.37 (1.25)	0.65 (1.96)	−0.72 (2.44)
	AERO	1.08 (1.32)	0.68 (1.25)	−0.40 (1.51)

CTL = control condition, ERGO = cycle ergometer exercise condition, AERO = slow aerobic dance condition.
DLPFC = dorsolateral prefrontal cortex, VLPFC = ventrolateral prefrontal cortex, FPA = frontopolar area.
†: $P < 0.05$ vs. ERGO.

Discussion

In the present study, we compared the effect of an acute bout of a novel, slow aerobic dance protocol and low-intensity cycle exercise on mood and executive function in older adults, when exercise tempo was held relatively constant. We found that slow aerobic dance increased vitality and pleasure levels to a greater extent than low-intensity cycle exercise, suggesting that slow aerobic dance can be used to improve mood in older adults. However, neither cycle exercise nor slow aerobic dance influenced levels of arousal, Stroop interference time, or Stroop interference-related oxy-Hb change. These results are inconsistent with those of our previous study, in which we observed that low-intensity cycle exercise increased arousal level and enhanced executive function[3)]. One possible reason for this inconsistency is the difference in participant age between the present and previous study[3)]. That is, low-intensity exercise may be insufficient to increase arousal level in older adults.

Moreover, the lack of increase in arousal level observed in the present study may have been associated with the relatively low tempo of exercise (90 bpm). In our previous study, participants performed cycle exercise at 120 bpm (= 60 rpm). As research has indicated that slow-tempo exercise does not increase arousal level[8)], the exercise tempo utilized in the present study may have been insufficient for increasing levels of arousal and producing cognitive improvements.

In addition, proficiency in performing the slow aerobic dance routine may have affected the results. Although participants practiced the slow aerobic dance routine once prior to the experimental condition, there were great differences in skill among participants, some of whom were unable to perform well. Previous studies have revealed that individuals with positive evaluation of their own performance exhibit increases in positive mood[2)]. Therefore, additional practice sessions or modifications to simplify the rhythmic exercise routine may be necessary.

In accordance with these hypotheses, we observed that participants who exhibited increased arousal following cycle exercise and performed well during the slow aerobic dance condition tended to exhibit shorter Stroop interference times (data not shown).

Furthermore, inadequate control of experimental conditions may have also masked the effects of exercise. First, habituation effects may have occurred during the Stroop task. Despite no significant main effect of time, Stroop interference time and Stroop-interference-related oxy-Hb change tended to decrease in almost all regions, for all conditions. Second, participants' intra individual difference in mood state before pre-Stroop task existed among the conditions, which may have influenced our findings.

In summary, our findings indicate that a slow aerobic dance protocol can significantly improve mood in older adults when compared with cycle exercise at a comparable intensity and tempo. However, we were unable to observe improvements in executive function following either exercise condition. This may have been due to several parameters, such as exercise tempo, exercise proficiency, and insufficient control of experimental conditions. Thus, further research is required to clarify the impact of tempo and exercise proficiency level on mood and executive function in older adults under strictly controlled experimental conditions.

References

1) American College of Sports Medicine (2010): ACSM's Guidelines for Exercise Testing and Prescription (8th ed). Lippincott Williams & Wilkins, Philadelphia.

2) Bartholomew, J.B. and Miller, B.M. (2002): Affective responses to an aerobic dance class: the impact of perceived performance. Res. Q. Exerc. Sport, **73**, 301－309.

3) Byun, K., Hyodo, K., Suwabe, K., Ochi, G., Sakairi, Y., Kato, M., Dan, I., and Soya, H. (2014): Positive effect of acute mild exercise on executive function via arousal-related prefrontal activations: an fNIRS study. Neuroimage, **98**, 336－345.

4）Colcombe, S.J., Erickson, K.I., Raz, N., Webb, A.G., Cohen, N.J., McAuley, E., and Kramer, A.F.（2003）: Aerobic fitness reduces brain tissue loss in aging humans. J. Gerontol. A Biol. Sci. Med. Sci., **58**, 176－180.

5）Gray, J.R., Braver, T.S., and Raichle, M.E.（2002）: Integration of emotion and cognition in the lateral prefrontal cortex. Proc. Natl. Acad. Sci. U. S. A., **99**, 4115－4120.

6）Hyodo, K., Dan, I., Kyutoku, Y., Suwabe, K., Byun, K., Ochi, G., Kato, M., and Soya, H.（2016）: The association between aerobic fitness and cognitive function in older men mediated by frontal lateralization. Neuroimage, **125**, 291－300.

7）Hyodo, K., Dan, I., Suwabe, K., Kyutoku, Y., Yamada, Y., Akahori, M., Byun, K., Kato, M., and Soya, H.（2012）: Acute moderate exercise enhances compensatory brain activation in older adults. Neurobiol. Aging, **33**, 2621－2632.

8）Naruse, K. and Hirai, T.（2000）: Effects of slow tempo exercise on respiration, heart rate, and mood state. Percept. Mot. Skills, **91**, 729－740.

9）Sakairi, Y., Nakatsuka, K., and Shimizu, T.（2013）: Development of the Two-Dimensional Mood Scale for self-monitoring and self-regulation of momentary mood states. Jpn. Psychol. Res., **55**（4）, 338－349.

10）Tamura, M., Nemoto, K., Kawaguchi, A., Kato, M., Arai, T., Kakuma, T., Mizukami, K., Matsuda, H., Soya, H., and Asada, T.（2014）: Long-term mild-intensity exercise regimen preserves prefrontal cortical volume against aging. Int. J. Geriatr. Psychiatry, **30**, 686－694.

11）Tsuzuki, D., Jurcak, V., Singh, A.K., Okamoto, M., Watanabe, E., and Dan, I.（2007）: Virtual spatial registration of stand-alone fNIRS data to MNI space. Neuroimage, **34**, 1506－1518.