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Effects of Acute Exercise on Concentration Performances

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Abstract

All types of exercise were effective in increasing or maintaining global cognition and neuroplasticity in areas of the brain associated with executive function and memory in elderly individuals, irrespective of their health status. In general, learning and memory require concentration; however, the direct impact of physical exercise on concentration skills has not yet been clarified. Therefore, the present study examined the effects of acute exercise on concentration. Eighteen healthy young adults were included in this study. Exercise habits were assessed prior to the experiment. The experiment consisted of two conditions: exercised and non-exercised. The participants were asked to perform 100 squats at a pace of approximately 2 s each as aerobic-resistance exercise during the exercise condition and were asked to rest with their eyes closed and without thinking for 5 min during the rest condition. The Trail Making Test was performed under pre- and post-conditions. The number of incorrect responses, execution times, and pencil releases were recorded. Additionally, blood pressure, pulse rate, and blood oxygen concentration were measured both before and after the exercise to confirm the exercise load. Wilcoxon's signed-rank test was used to examine changes in biological responses and concentration performance between the pre- and post-conditions. The systolic blood pressure, pulse rate, and blood oxygen concentration increased significantly after exercise. However, no improvement in concentration performance was observed in both conditions. This result may be due to factors such as the intensity of exercise. Further research with adjusted exercise intensity is needed to clarify the phenomenon and discuss further.

Keywords

Exercise, Concentration, Cognitive Function, Brain Function, Blood Pressure

1. Introduction

Previous studies have investigated the effects of physical exercise on cognitive function. Systematic reviews have indicated that various types of exercise are effective in improving or maintaining global cognitive performance. Among these, resistance exercise demonstrated the highest probability of being the most effective intervention for slowing declines in global cognition, executive function, and memory in patients with cognitive impairment [1]. In addition, aerobic exercise, particularly when performed for 30 minutes per session, less than 150 minutes per week, and up to three times per week—has been shown to improve cognitive function in patients with Alzheimer's disease [2].

Normal aging is associated with gradual brain atrophy [3], while aerobic exercise training is effective in reversing hippocampal volume loss in late adulthood, which is accompanied by improved memory function [4]. Previous research using neuroimaging systems has shown that physical exercise improves attentional function and information-processing speed throughout life [5]. Moreover, a meta-analysis has shown that physical exercise enhances memory [6]. Physical exercise affects the molecular pathways involved in synaptic functions underlying learning and memory [5]. Collectively, this review article suggests that exercise can enhance cerebrovascular function, cognition, and neuroplasticity in areas of the brain associated with executive function and memory in adults aged 50 years or older, regardless of their overall health status. However, it also pointed out that further research is required to elucidate the mechanisms of action [7].

In general, learning and memory require concentration; however, the direct impact of physical exercise on concentration skills remains unclear. Therefore, we hypothesized that physical exercise would improve concentration skills. To clarify this issue, we focused on the immediate effects of acute exercise. Therefore, this study aimed to examine the effects of acute exercise on cognitive performance.

2. Materials and Methods

2.1. Participants

This study enrolled 18 healthy young adults (5 women and 13 men; age: 20.89 ± 0.68 years). All prospective participants were provided with a comprehensive explanation of the study's safety protocols and were assured that their personal identifying information would remain confidential. Subsequently, they provided written informed consent for participation in the study. Additional informed consent was obtained from all the participants whose identifiable information was included in this study. None of the participants had a history of major physical disorders or lower leg injury. This study was approved by the Ethics Committee of Nishikyushu University (approval no. 24FNA38) and conformed to the principles of the Declaration of Helsinki and its subsequent amendments [8].

2.2. Experimental Protocol

Prior to the experiment, exercise habits were assessed using a standard questionnaire for specific health checkups (Q 10-12) (**Table 1**). The experiment consisted of two conditions: exercised and non-exercised. All participants participated in both conditions. The participants were asked to perform 100 squats at a pace of approximately 2 s each as aerobic-resistance exercise during exercise conditions and were asked to rest with their eyes closed and without thinking for 5 min during the rest condition. They were not required to engage in any other exercise that would cause them to become out of breath for three hours immediately prior to the experiment.

Table 1. Exercise habit checklist.

Questionnaires		answer: yes	answer: no
Q10	Exercise for at least 30 minutes at a time, breaking a light sweat, at least two days a week, for at least one year	0	18
Q11	Walking or equivalent physical activity for at least one hour per day in daily life	9	9
Q12	Walks faster than people of the same age and sex	9	9

A concentration task was performed under pre- and post-conditions. The Trail Making Test (TMT), Part B, was used as the concentration task. The participants were asked to alternate between numbers and letters when connecting different items in ascending order (*i.e.*, 1, A, 2, B, etc.) [9]. As the concentration performance was evaluated, the number of incorrect responses, execution time, and the number of pencil releases (breaking the rules) were also assessed. In addition, blood pressure (BP), pulse rate (PR), and blood oxygen concentration (SpO_2) were measured pre- and post-conditions to confirm the exercise load. An arm-in BP monitor ES-P2020ZZ (Terumo Corporation, Tokyo, Japan) was used to measure BP and PR, and an oxygen saturation meter PLS01P (Muranaka Medical Equipment Co., Ltd., Osaka, Japan) was used to measure SpO_2. Moreover, a 1 h interval was set between each condition for the washout period. The order of the conditions was counterbalanced.

2.3. Data Analysis

Biological response and task performance data were averaged across all participants at each time point.

2.4. Statistical Analysis

Wilcoxon's signed-rank test was used to examine changes in biological responses and concentration performance between the pre- and post-conditions. Statistical analyses were performed using IBM SPSS Statistics (version 29.0, IBM Corp., NY, USA), with a statistical significance level of $P < 0.05$.

3. Results

Table 2 shows a comparison of the pre- and post-conditions for each condition.

Table 2. Comparison of pre- and post-conditions within each condition.

Outcomes	Exercise condition		Non-exercise condition	
	pre	post	pre	post
Systolic BP (mmHg)	121.06 ± 20.42*	145.17 ± 25.55	121.44 ± 15.76*	113.67 ± 12.55
Diastolic BP (mmHg)	66.89 ± 12.67*	49.89 ± 12.28	66.17 ± 11.39	65.61 ± 7.40
PR (beats/min)	75.33 ± 13.74*	133.89 ± 25.00	74.83 ± 10.63	76.72 ± 10.08
SpO_2 (%)	98.39 ± 1.46*	99.33 ± 0.75	98.22 ± 1.36	98.11 ± 1.41
Execution time (sec)	37.70 ± 7.95	38.44 ± 6.40	42.07 ± 11.50	43.92 ± 14.26
Number of incorrect responses (times)	0.50 ± 0.50	0.17 ± 0.50	0.33 ± 0.47	0.56 ± 0.76
number of pencil releases (times)	0.17 ± 0.37	0	0.11 ± 0.31	0

Significant differences or trends are indicated (*$P < 0.05$, Wilcoxon signed-rank test).

Systolic BP, PR, and SpO_2 all increased significantly in post-exercise conditions compared with pre-exercise condition ($P < 0.01$), while diastolic BP decreased significantly ($P < 0.01$), confirming that the exercise load was appropriately imposed. In contrast, only systolic BP decreased significantly in post-non-exercise conditions compared with pre conditions ($P < 0.01$).

Regarding the results of the concentration task, no significant changes were observed in both conditions ($P > 0.05$).

4. Discussion

This study examined the effects of acute exercise on concentration performance. The increase in PR and systolic BP immediately after exercise can be interpreted as exercise load, and the results showed that the number of incorrect responses on the TMT-B and pencil release tended to decrease immediately after acute exercise.

The fact that this study showed no improvement in concentration performances. Previous research using the Stroop Test has shown that brain activation in the left dorsolateral prefrontal cortex is significantly enhanced after acute exercise, and this activation is consistent with improved cognitive ability [10]. It is believed that the concentration performance observed in this study also reflects similar neural bases. A meta-analysis also showed that acute moderate exercise can selectively enhance executive function [11]. Moreover, previous research has shown that moderate exercise is more likely to lead to improved behavioral performance than high-intensity exercise [11].

The reason for the lack of improvement in the concentration performance in this study may be that exercise intensity was not adjusted to be moderate for the subjects. In terms of exercise style, the squats in this study combined aerobic-resistance exercise with continuous rhythmic exercise, which is consistent with a recent meta-analysis showing that even acute resistance exercise can improve executive function [12]. Therefore, short-term aerobic-resistance exercise can be considered a practical measure to improve quality by suppressing errors and stabilizing attention. However, adjustments to exercise intensity may be necessary to enhance concentration performance.

This study had some limitations. First, the concentration task was limited to the TMT. Second, adjustments in the exercise intensity are necessary. Third, the sample size was small. To address these limitations, future studies should adjust the exercise intensity and conduct various concentration tasks with a larger number of participants. In conclusion, no improvement in concentration performance was observed. This result may be due to factors such as the intensity of exercise. Further research with adjusted exercise intensity is needed to clarify the phenomenon and discuss further.

Authors' Contributions

MM and KN: Conceptualization, methodology, investigation, resources, data curation, visualization, supervision, project administration (original draft preparation), and writing (review and editing). TH: Validation, formal analysis, writing, editing, and review. All the authors have read and agreed to the published version of this manuscript.

Institutional Review Board Statement

This study was approved by the Ethics Committee of Nishikyushu University (approval no. 24FNA38).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The datasets generated and analyzed in the current study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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