Research Paper

Comparing the Effects of Resistance Training and Aerobic Exercise With Low and Moderate Intensities on Working Memory and Selective Attention of Inactive Young Girls

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ABSTRACT

Background and Purpose: In recent years, new approaches such as physical activity hold promise as non-pharmacological interventions that have gained popularity in improving information processing and cognition. Besides examining the positive effect of long-term activities, researchers have recently noticed the advantages of one session of physical activity on cognitive performance. Considering the importance of this subject, the present study aimed to investigate the effectiveness of one session of aerobic and resistance training with low and moderate intensity on working memory and selective attention of young girls.

Materials and Methods: This quasi-experimental study, with a pre-test and post-test design, was conducted in 2019-2020. A total of 16 women (age range of 25-30 years old) were selected by the available sampling and participated in the training sessions of aerobic exercise (with low intensity of 45%-55% and moderate intensity of 60%-65% of heart rate reserve) and resistance training (low intensity with 40%-50% of one repetition maximum (1RM) and moderate intensity with 60%-70% of 1RM) in the counterbalance method. The Stroop and n-back tests were measured in the pre-test and post-test. The study was conducted on the subjects sitting at the table, and the material's content was psychologically neutral. Repeated measures analysis of variance was used for statistical analysis of data.

Results: Short-term aerobic and resistance exercise with low and moderate intensity positively and significantly affects working memory ($P \leq 0.05$). However, no significant difference was found between training groups in working memory ($P \geq 0.05$). Also, the findings showed that physical activity does not significantly affect selective attention ($P \geq 0.05$).

Conclusion: One session of aerobic and resistance exercise appears to positively affect working memory, but it does not significantly affect selective attention. Thus, it can be said that the mechanisms involved in improving working memory and selective attention are probably different.

Keywords: Executive functions, Working memory, Selective attention, Aerobic exercise, Resistance exercise

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Introduction

Executive functions refer to a group of organizational and integration abilities controlled by different brain areas, such as the prefrontal cortex and hippocampus at the neurological and anatomical level. These areas control and facilitate other cognitive processes [1]. This cognitive structure is in charge of important tasks such as problem-solving, attention, reasoning, organization, planning, memory, response inhibition, impulse control, maintaining the intention, and changing the learning intention [2, 3].

Working memory is one of the essential components of executive functions. It is a system for storing and processing information related to the task. It works simultaneously with implementing a cognitive process and is very important in solving complex cognitive tasks, such as understanding spoken and written language, mental calculation, reasoning, and problem-solving [4]. Another critical dimension of executive functions is attention, which leads to awareness of time and place. The selective nature of attention plays a vital role in everyday life, as it enables the accurate processing of stimuli in the environment, allowing essential reactions and decisions [5].

In recent years, the tendency to use different approaches to examine and improve executive functions has increased due to its importance. One of the most recent approaches is cognitive rehabilitation using exercise and physical activity [6, 7]. Researchers have shown that regular physical activity controls the maintenance, growth, and differentiation of synapses and neurons. Angiogenesis improves cognitive functions such as processing speed, controls, planning, and working memory [8]. In addition to investigating the positive effect of long-term activities, the beneficial effects of one session of physical activity on cognitive and mental performance have recently been the focus of researchers [9]. However, recent studies show that the rate of improvement in cognitive performance through physical activity may be related to the motor characteristics of the activities performed [10, 11]. For example, Mehren et al. have shown that aerobic exercise increases arousal and catecholamine, which is associated with the brain's frontal cortex and affects executive functions [12]. Resistance training may also affect neural communication, information processing, and brain-derived neurotrophic factor production [13]. Besides the type of exercise, the intensity of exercise is another variable affecting executive functions. It seems that the intensity of short-term exercise affects cognitive performance in the form of an inverse U function, and moderate-intensity exercise with an intensity of 40%-85% of VO_{2max} improves cognitive performance [8, 14]. According to the literature, most studies have focused on the effect of long-term exercises on the components of executive functions. However, new studies have shown the researchers' interest in short-term and one-session exercises on various components of executive functions [15].

Few studies have directly compared the effect of one aerobic and resistance training session. Tsuk et al. [16] showed that one acute resistance training session increases the score on the attention test and executive functions. In contrast, one aerobic training session only improves the scores of executive functions. The result of Wu et al. show that in the comparison of acute aerobic exercise (cycling with 60%-70% of the heart rate reserve for 30 minutes) and resistance exercise (seven trainings with two sets of 8-12 repetitions with a maximum of 70% of 10 repetitions), has positive effects on cognitive performance [17]. However, the Loprinzi study showed that the 15-minute acute aerobic and resistance training had no significant impact on the episodic memory performance of young adults [18]. Croce et al. [19] investigated aerobic exercise with three different intensities (low, moderate, and high intensity) on information processing speed. They employed a response time paradigm on 27 (18 to 26 years old) adults.

Study samples participated in single choice (SC), multichoice (MC), and dual-task (DT) performance before exercise and 1 min and 20 min after the exercise on a bike ergometer. Then, their processing speed was analyzed by calculating total response time (RPT), reaction time (RT), and movement time (MT) on a response time apparatus. Based on the results, the RT and RPT values of the participants in each exercise condition improved on MC and DT tasks but not on the SC task. Also, the improvements were observed immediately (1 min) and short-term (20 min) after the exercise [19]. Ren et al. studied the effect of 30 minutes of aerobic and resistance exercises on the Tower of London test (TOL) in 30 children with preterm birth. Compared with the control group, after acute aerobic and resistance exercises, the TOL task yielded a lower total score, a shorter total executive time, and problem-solving time [20]. Also, Li et al. investigated the effect of acute exercise type on cognitive flexibility. A total of 78 young adults were divided into the following groups: Combined exercise (CE), aerobic exercises (AE), and reading control (RC). The results showed that acute CE and AE shortened response times regardless of test conditions compared to the RC group. Also, higher P3 amplitude was observed after CE in the heterogeneous condition and under AE in the switch condition [21].

Although short-term exercise changes cognitive functions, the influence of exercise intensity and type on executive functions has not been discussed. In addition, previous research related to the intervention of sports training and executive functions has provided relatively little information about this issue. Few studies that have examined the effect of acute aerobic and resistance exercises on executive functions have reported that different methods may moderate the relationship between acute activity and different aspects of executive functions and that different intensities may have different effects on executive functions . Reviewing the previous research shows that using appropriate processes that improve executive functions is crucial, and executive functions are essential for success in different dimensions of life, including career and academic success, interpersonal relationships, social skills, and daily activities. It seems that conducting such studies will help rehabilitation specialists and teachers design a suitable exercise program to improve working memory and selective attention. On the other hand, more studies are needed due to the contradiction in the findings and the existing gap. Thus, the present research aimed to investigate the effect of different intensities (moderate and low) of aerobic and resistance training on working memory and selective attention of inactive young girls.

Materials and Methods

This applied research has employed a quasi-experimental design. We used a within-subjects design with a counterbalanced order. The study's statistical population comprised all female students of Yazd University, Yazd City, Iran, who had no regular sports activities. They were 25-30 years old. A total of 16 healthy girls (9 PhD students and 7 master's students) voluntarily participated in this study. After selecting the subjects, they were provided with a personal profile form and a consent form, explaining the research goals, necessity, and characteristics. Also, the participants were assured that they would not have any physical problems in this research and the information would be kept confidential. The inclusion criteria were providing the consent form to participate in the study, lacking regular physical activity, not smoking, lacking physical, behavioral disorders, or cognitive disorders, having proper health status to participate in the exercises, and lacking neurological, cardiovascular, or respiratory diseases. The exclusion criteria included not cooperating in continuing the research, being absent in training sessions, developing injuries, or catching diseases that prevented them from participating in this experiment.

Demographic information

The demographic form included questions such as age, weight, height, gender, level of education, declaration of physical and cognitive illness, etc.

General health questionnaire

Goldberg and Hiller presented the 28-question general health questionnaire (GHQ) in 1979. It has four subscales: Physical symptoms, symptoms of anxiety and sleep disorders, social functioning, and symptoms of depression. Each subscale contains 7 questions. The questions are scored on a 4-point Likert scale (0-3), so a person's total score will vary from 0 to 84. In the present study, a score higher than 23 (cutoff point) allows the person to enter this study. Taghavi confirmed the validity and reliability of this questionnaire in Iran [22]. In the present study, the reliability coefficients of the GHQ were obtained from 0.77 to 0.86 using the Cronbach α method for the test subscales.

International physical activity questionnaire

The international physical activity questionnaire (IPAQ) was designed to measure the amount of physical activity, and the questions were about people's activity during the past seven days. The short version of the IPAQ contains 7 questions and was created by the international expert group (1998), whose validity and reliability have been confirmed in different countries [23]. The Iranian version of this questionnaire was reviewed by Baghiani Moghadam et al., and its content validity was 0.85. Its internal consistency was obtained using the Cronbach α coefficient of 0.7 [24]. In the present study, the reliability of the questionnaire was obtained at 0.81 using the test re-test method.

N-back working memory test

This test was designed for the first time by Kirchner [25], and its computerized version was used by Jaeggi et al. [26]. Since this task includes keeping cognitive information and manipulating, it is very suitable for measuring working memory performance. In the N-back test, a sequence of visual stimuli appears on the monitor screen one after the other. The task is to decide whether the displayed stimulus is the same as the previous N sequences. The validity and reliability of this test have been acceptable as an indicator of working memory performance [10]. In our country, the reliability coefficient of the tool, from 0.54 to 0.84, shows the test is highly reliable, and the reliability coefficient is 0.87 [27]. In the present study, the reliability of the test was obtained at 0.74 using the test re-test method.

Complex Stroop test

Ridley Stroop introduced the Stroop test in 1935 to measure selective attention through visual processing. A number of 240 consonant and 240 non-consonant color words with red, blue, yellow, and green colors (480 words in total) are shown to the subjects in an overlapping and sequential manner. The subject's task is to base the answer on the color of the word, regardless of the meaning of the word. In our country, the reliability of the test through re-testing has been reported to range from 0.80 to 0.91 in adults and children [28]. The test re-test method showed the reliability of the test as 0.71.

Polar heart rate monitor

To measure the heart rate, a polar heart rate monitor made in Finland was used, including a wrist monitor and a sensor worn on the chest. It can wirelessly show the heart rate during activity.

Exercise protocol

An aerobic training session consisted of 5-10 minutes of warm-up, 30 minutes of treadmill running, and 5 minutes of cool-down. Subjects' heart rate was controlled according to the desired intensity in the range of 60%-65% reserved for moderate intensity and 45%-55% for low intensity by changing the treadmill's speed. The Equation 1 was used to calculate the maximum heart rate of the subjects.

1. $[208-(Age\times 0.7)]$

The Karvonen method Equation 2 was used to calculate heart rate reserve.

2. $\{Target\ heart\ rate\ (HR)=[(Max\ HR - Resting\ HR)\times\%\ Intensity]+resting\ HR\}$

A trainer monitored all training sessions. During the entire training period, a polar heart rate monitor was used to check the subjects' heart rate, and its monitor was placed on the treadmill so that the subject and the researcher could see the heart rate. In addition to the heart rate monitor, the Borg rating of perceived exertion (RPE) (6-20) was also used to monitor the exercise intensity of the subjects during the exercise [29, 31].

A resistance training session started with a 5-10 minutes warm-up with stretching exercises. Then, the participants performed resistance exercises in three sets of 12-15 repetitions with 60%-70% 1RM (one repetition maximum) of moderate intensity and 40%-50% of 1RM of low intensity. The participants rested for 1 minute between each set of 12-15 repetitions and 3 minutes between performing the movements of different muscle groups. At the end of the training session, they did a 5-minute cool-down. The movements performed in resistance training included chest press, leg press, vertical pull, chest pull, leg pull, and shoulder press, which the trainer taught me how to perform correctly [16, 31]. To calculate 1RM, the Equation 3 was used:

3. $W\times(1+0.0333\times R)=1RM$

(W=weight of the weight and R=number of repetitions of the weight).

Research implementation method

In the first session, in addition to full explanations of the implementation method and the purpose of the research, the questionnaires were given to the subjects to be completed, and their height and weight were also measured. Then, selective attention and working memory pre-tests were taken from all participants using computer software, and the results were recorded. Sixteen participants performed resistance and aerobic exercises with low and moderate intensity, as well as control conditions, in a counterbalanced manner and at intervals of several days to prevent learning and familiarization with the test [17]. The first session was familiarization with the test and its objectives, and the second session included the pre-test. The subsequent sessions included aerobic and resistance training with low and moderate intensity and control conditions in the counterbalance method. In this way, the subjects were placed in groups of three or four and performed one type of exercise during each session. After the exercise, the subjects took a rest, and after the heart rate returned to the baseline state (about 15-20 minutes), memory and selective attention tests were taken.

We used descriptive and inferential statistics to analyze and categorize the obtained data. The Shapiro-Wilk statistical test was used to check the normality of data distribution. Repeated measurements analysis of variance and Bonferroni post hoc tests were used for statistical analysis of data in SPSS software, version 24.

Results

Table 1 presents the demographic characteristics of subjects as well as their GHQ and IPAQ scores. Table 2 presents the correct answer selection scores and the subjects' interference scores in different resistance and aerobic training conditions.

Figure 1 shows the mean scores of correct answers (working memory) of subjects in the pre-test and post-test stages in different conditions. According to Figure 1, in the correct answer selection score, all exercise groups progressed from the pre-test to the post-test, and the moderate-intensity resistance and moderate-intensity aerobic groups performed relatively better in the post-test.

Figure 2 shows the mean interference scores (Stroop test) in different conditions in the pre-test and post-test stages. According to Figure 2, the post-test scores of the groups (except for the low-intensity resistance group) have slightly decreased in the post-test compared to the pre-test, and the largest decrease is related to the moderate-intensity resistance and moderate-intensity aerobic groups.

In the inferential statistics, the variable scores of the correct answer choice related to the working memory test were compared under different conditions using the statistical test of analysis of variance with repeated measurements. The results of the test, considering its defaults, are shown in Table 3.

According to Table 3, the results show a significant difference between working memory scores in different conditions. Considering the significance of the correct answer scores in various conditions, to check which condition has a significant difference, the Bonferroni post hoc test was used, and its results are presented in Table 4.

Table 4 indicates significant differences between performance scores in the pre-test with all performance conditions except the control condition. Also, the results show no significant difference between two exercise groups. To compare the scores of the variable of selective attention in the Stroop test in different conditions, repeated measures analysis of variance was used (Table 5).

Table 1. Demographic characteristics of subjects

No.	Mean±SD				
	Age (y)	Weight (kg)	Height (cm)	GHQ Score	IPAQ Score
16	27.62±2.02	60.56±6.80	164.81±6.19	16.43±3.84	503.75±44.85

GHQ: General health questionnaire; IPAQ: International physical activity questionnaire.

Table 2. Mean±SD of research variables

Variables	Time Steps	Situation	Mean±SD
Correct answer (working memory)	Pre-test	-	40.12±1.62
	Post-test	Control group	40.56±1.15
		Low-intensity resistance	41.12±0.8
		Moderate-intensity resistance	41.43±0.72
		Low-intensity aerobic	40.93±1.06
		Moderate-intensity aerobic	41.37±0.71
Interference score (selective attention)	Pre-test	-----	3.87±2.37
	Post-test	Control group	3.47±2.25
		Low-intensity resistance	2.65±1.50
		Moderate-intensity resistance	2.98±1.12
		Low-intensity aerobic	2.36±1.37
		Moderate-intensity aerobic	2.03±1.43

GHQ: General health questionnaire; IPAQ: International physical activity questionnaire.

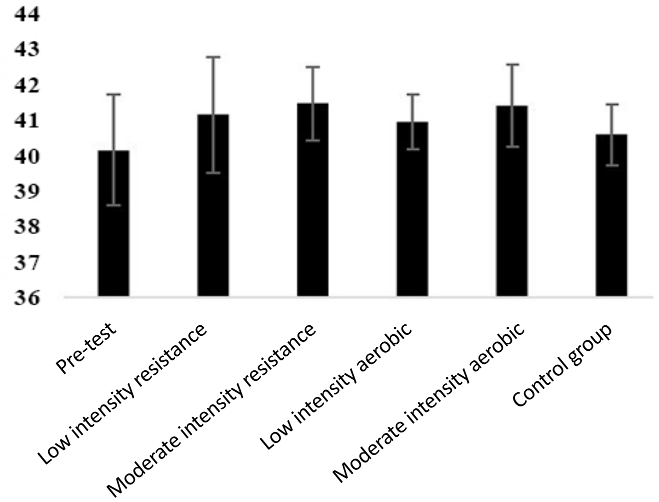

Figure 1. Mean scores of correct answers in the pre-test and post-test stages in different conditions

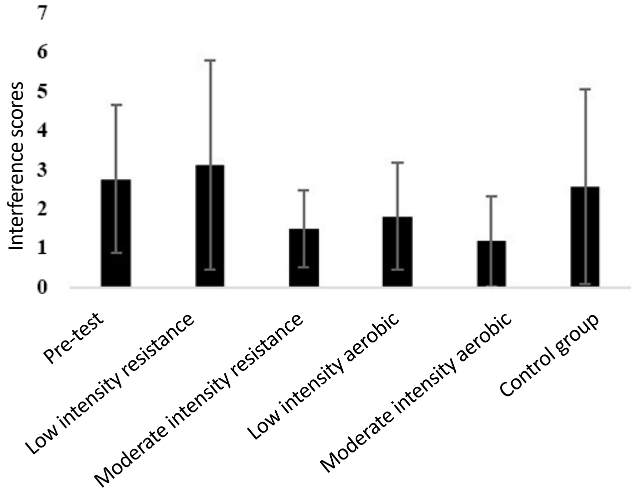

Figure 2. Mean in the pre-test and post-test stages in different conditions

The results of Table 5 show no significant difference between the selective attention scores in different conditions.

Discussion

The present study showed a significant difference between the scores of choosing the correct answers of the working memory test in the pre-test and the post-test. Therefore, one intense training session, aerobic or resistance, affects working memory similarly.

Studies of long-term exercise (in animal models) suggest that the mechanisms (and possibly the outcome) through which exercise affects memory may be specific to aerobic and resistance exercise [18]. However, this effect did not occur for acute exercise on memory. Some researchers have reported that acute aerobic and resistance exercises favorably promote neural plastic-

Table 3. The results of the analysis of variance test with repeated measurements for working memory

Parameter	Sum of Squares	df	Mean of Squares	F	P	η^2
Time	160802.52	1	160802.52	56107.5	0.001	0.35
Error	42.99	15	2.866	--	--	

Table 4. The results of Bonferroni post hoc test for changes in working memory scores between different conditions

Situation		Mean±SE	P
Pre-test	Control	-0.438(0.376)	0.263
	Low intensity resistance training	-1(0.342)	0.010
	Moderate intensity resistance training	-1.313(0.384)	0.004
	Low intensity aerobic training	-0.813(0.332)	0.027
	Moderate-intensity aerobic training	-1.250(0.371)	0.004
Control	Low-intensity resistance training	-0.563(0.353)	0.132
	Moderate-intensity resistance training	-0.575(0.272)	0.126
	Low-intensity aerobic training	-0.375(0.340)	0.278
	Moderate intensity aerobic training	-0.413(0.306)	0.108
Low-intensity resistance training	Moderate-intensity resistance training	-0.313(0.270)	0.264
	Low-intensity aerobic training	-0.188(0.319)	0.566
	Moderate-intensity aerobic training	-0.250(0.233)	0.300
Moderate-intensity resistance training	Low intensity aerobic training	0.5(0.258)	0.072
	Moderate-intensity aerobic training	0.063(0.249)	0.806
Low-intensity aerobic training	Low-intensity aerobic training	-0.438(0.241)	0.089

Table 5. The results of the analysis of variance with repeated measurements for the Stroop test

Parameter	Sum of Squares	df	Mean of Squares	F	P	η^2
Time	20.80	2.11	9.82	1.03	0.37	0.06
Error	303.03	31.77	9.53	-	-	

ity, cerebral blood flow, oxygenation, and neurogenesis, which may affect memory performance. Aerobic and resistance exercises enhance memory performance by activating similar and unique mechanical pathways [13, 32]. This improvement has been attributed to changes in brain systems that influence how mental resources are allocated to the performance of cognitive tasks [33]. A possible explanation for the lack of difference in the effectiveness of the aerobic and resistance exercises may be that the two exercise methods used in our study had a similar level of cognitive demand. The present study's findings are consistent with the results of Loprinzi et al. [34] and Wu et al. [17]. Loprinzi et al. [34] investigated the effect of aerobic and resistance training on episodic memory, which showed that both trainings create positive responses in the brain. They stated that the results may be due to increased cerebral blood flow: Potential mechanisms include increased arousal, neurogenesis in the hippocampus, neuronal electrical changes, and protein production. In addition, some researchers believe that resistance exercise can lower inflammatory markers that contribute to neural communication while increasing peripheral and central brain-derived neurotrophic factors (BDNF) [30].

The researchers also suggested a mechanism for improving cognitive performance after aerobic exercise. The mechanism is the physical stress that activates the sympathetic system and the pituitary axis of the hypothalamic adrenal gland (HPA). Stress hormones released after activating the HPA axis and the sympathetic system, such as cortisol and noradrenaline, impact cognitive function, respectively [16].

Physical activity improves brain adaptation and directly impacts neurocognitive functioning. Functional magnetic resonance imaging has also shown that acute exercise activates the prefrontal cortical area and enhances executive functions [20].

In summary, the evidence shows cerebral blood flow increases during short-term exercise, leading to PFC changes that improve various cognitive components [16]. Also, a possible explanation for the positive effects of acute exercise on cognitive performance may be related to the stimulation of brain areas involved in motor and cognitive processes and neurochemical actions such as BDNF, insulin-like growth factor-1, and serotonin. BDNF is a growth factor that leads to neural plasticity and synaptic growth as well as transmission and improves cognition due to its role in angiogenesis [33]. Recent research using non-human animal models has found a positive correlation between aerobic exercise and biochemical substances that activate neuronal proliferation (such as BDNF) and serotonin. Also, serotonin and BDNF are associated with neurogenesis in the hippocampus of animals involved in the working memory tasks. The hippocampus is a complicated part of the brain and a pivotal component in memory formation and retrieval. Also, it seems to be highly plastic to intervention [36].

The present study's results contradict Tsuk et al.'s findings [16] as they did not report the same effect of aerobic and resistance exercises on executive functions. It is also inconsistent with the results of Loprinzi et al. [18] that acute exercise does not affect memory. The researchers stated that the reason for the contradiction in the results might be due to differences in the intensity and duration of exercise, the type of cognitive task, and the duration of the recovery period [8].

Regarding training intensity, the results are consistent with the findings of Shaabani et al., who showed that acute resistance training with low and moderate intensity improved working memory similarly [37]. The result of the present study was inconsistent with the results of Naderi et al. Their research investigated the effects of one-session resistance training with low and moderate intensity on executive functions in the elderly community. They showed that low- and moderate-intensity resistance training positively affected executive functions, but the effect of high-intensity training is greater than that of low-intensity training [38].

Although researchers have stated that moderate-intensity aerobic exercise may significantly increase cerebral blood flow [39] and cognitive performance improves and reaches its peak by increasing physiological arousal to optimal levels, there were no differences between the different intensities in the present study. The results contrast the inverted U-shaped curve proposed by Audiffren [40], in which low- and high-intensity training sessions are expected to produce transient cognitive improvements. At the same time, greater changes may occur after moderate-intensity training [35]. Such inconsistencies regarding the effects of acute exercise on cognition may be attributed to participant characteristics, the types of cognitive performance assessed, and the timing of exercise cessation to perform the cognitive task.

Also, the results showed no significant difference between the interference scores in the selective attention test and any exercises. After examining an acute aerobic training session against resistance training on attention, Tsuk et al. [16] found that an acute resistance training session increased the attention test scores, which is inconsistent with the results of the present study. In contrast, an aerobic training session had no positive effect on attention, which is in line with the results of the present study. In their research, Dunsky et al. [33] also studied the impact of one session of resistance and aerobic training with moderate intensity on adults' attention and executive performance. Finally, they found that contrary to aerobic training, one session of resistance training with moderate intensity had no significant effect on attention, which is consistent with the present study. They suggested that the improvement of attention with aerobic exercise is probably due to a biochemical process related to neurogenesis in the hippocampus and possibly plays a role in attention needs.

Hogan et al. reported that moderate aerobic exercise led to a decrease in reaction time among older people [41], which is not consistent with the results of the present study. One of the possible reasons for the contradiction in the results could be the training protocol, the evaluation tool, the age of the subjects, and the amount of training required to arouse and improve the subjects' attention with aerobic and resistance training. For example, older adults are cognitively weaker. They are affected by cognitive changes faster with a training session, but young people are at the peak of cognitive stability. They may need longer-term training to make positive changes. It should be mentioned.

In a meta-analysis study, Chang et al. [1] showed that one-session exercise has small to moderate positive effects on many cognitive functions in healthy adults. Previous studies and meta-analyses have shown that children and older people (groups with lower cognitive performance levels) benefit more from acute exercise. One of the factors influencing cognitive performance levels is the age of people [42], and in the present study, the subjects were young, so they had higher cognitive performance. Probably, these exercises did not affect people's attention. In addition, a large number of stimuli and lack of boredom may have led to a temporary state of mental fatigue and, thus, reduced motivation, which requires more research. It should also be mentioned that the effect of physical activity on executive function tasks may be selective, and it is not such that the impact of physical activity includes all the components and processes of executive functions, and different cognitive tasks lack the same sensitivity to physical activity [43]. Therefore, it can be explained that the type of physical activity and its mental origin may have led to the present result. Further studies are needed to understand how short-term exercise affects memory and selective attention. In summary, unlike the general effects of physical activity on cognitive function and related subdomains, optimal exercise parameters (intensity, duration, repetitions) and conditions (age, gender) are still unclear.

Conclusion

The present study revealed that one session of aerobic and resistance training with low and moderate intensity could improve the working memory of inactive girls, and the type of training and intensity do not matter. However, in the selective attention test, no significant effect was found between any resistance and aerobic groups with low and moderate intensities, so the results require more research to identify possibly different mechanisms involved in improving working memory and selective attention. Considering the importance of increasing cognitive performance in various fields, including academic and career success, it is suggested that coaches and teachers use aerobic and resistance exercises to improve the working memory of young girls.

Despite the practical results and the presentation of new findings, the current research had some limitations. First, we can mention the small number of subjects and the specificity to a certain gender and age. The statistical sample of the current research was young girls with an age range of 25-30 years, and the generalization of their data to other age groups should be done with caution. Lack of accurate control of some influential variables, including diet, the mental state during the test, and self-motivation, may affect the findings. Also, due to the research being conducted during the COVID-19 pandemic, the research was conducted using a counterbalancing method. It is suggested that future research should use a larger sample size and in separate groups and examine other components of executive functions in other age groups. Also, more research on the effectiveness of time and different intensities and comparing it with other exercises, including periodic and continuous exercises, etc., on executive functions is needed to achieve more reliable results.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Yazd University (Code: IR.YAZD.REC.1402.042). In addition, before conducting the study, the consent of the research subjects was obtained, and they were assured that the information would be confidential.

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Authors contributions

Study design: Mohammadreza Sadeghian Shahi and Hossein Samadi; Data collection: Zeynab Mirshejari and Mohammadreza Sadeghian Shahi;Implementation of the intervention and data analysis; Zeynab Mirshejari; Conceptualization and writing: Hossein Samadi.

Conflict of interest

The authors declared no conflict of interest.

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