

## The influence of 8 weeks of aerobic, strength and mixed exercises on the performance of short-term memory of women

### La influencia de 8 semanas de ejercicios aeróbicos, de fuerza y mixtos en el desempeño de la memoria a corto plazo de las mujeres

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**Abstract:** The purpose of this study was to investigate the effect of 8 weeks of aerobic, strength and mixed exercise on short-term memory performance of women. It is a quasi-experimental study accomplished by a pre/post-test plan with three experimental groups and one control group. A total of 60 female volunteers were selected, randomly, allocated to four groups including: aerobic group, strength group, aerobic-strength group and control group. All the groups performed their training protocols. Measurement of short-term memory performance was done using memory span test in two steps pre and post of exercise sessions. Data was analyzed using dependent t-test and covariance test. Least significance difference (LSD) test was used to compare groups. The results suggest that 8 weeks of aerobic ( $p=0.001$ ), strength ( $p=0.001$ ) and strength-aerobic ( $0.029$ ) exercise increases memory performance. The results of covariance test showed that 8 weeks of aerobic, strength and aerobic-strength exercise affect short-term memory of women differently. Also, the results of mean comparison test suggest that there is a significant difference between control, aerobic-strength and strength groups ( $p<0.05$ ). Clinically speaking, these findings prove the importance of aerobic, strength, and aerobic-strength exercise in preserving and improving memory performance.

**Keywords:** women, aerobic exercise, strength exercise, short-term memory.

**Resumen:** El propósito de este estudio fue investigar el efecto de 8 semanas de ejercicio aeróbico, de fuerza y mixto en el rendimiento de la memoria a corto plazo de las mujeres. Es un estudio cuasi experimental con un diseño pre / post test con tres grupos experimentales y un grupo control. Se seleccionaron 60 voluntarias, al azar, y se asignaron a cuatro grupos: grupo aeróbico, grupo de fuerza, grupo de fuerza aeróbica y grupo control. Todos los grupos realizaron sus protocolos de entrenamiento. La medición del rendimiento de la memoria a corto plazo se realizó mediante la prueba *memory span* en dos fases, antes y después de las sesiones de ejercicios. Los datos se analizaron usando la prueba de t de Student para muestras relacionadas y un análisis de la covarianza. Se utilizó el método de la diferencia menos significativa (LSD) para comparar grupos. Los resultados sugieren que 8 semanas de ejercicio aeróbico ( $p = 0,001$ ), de fuerza ( $p = 0,001$ ) y de fuerza aeróbica ( $0,029$ ) aumentan el rendimiento de la memoria. Los resultados del análisis de la covarianza mostraron que 8 semanas de ejercicio aeróbico, de fuerza y de fuerza aeróbica afectan la memoria a corto plazo de las mujeres de manera diferente. Además, los resultados de la prueba de comparación de medias sugieren que existe una diferencia significativa entre los grupos de control, de fuerza aeróbica y de fuerza ( $p < 0,05$ ). Clínicamente hablando, estos hallazgos demuestran la importancia de los ejercicios aeróbicos, de fuerza, y de fuerza aeróbica para preservar y mejorar el rendimiento de la memoria.

**Palabras clave:** mujeres, ejercicio aeróbico, ejercicio de fuerza, memoria a corto plazo.

## Introduction

At the moment, there is evidence that proves the benefit of exercise for brain performance (Fillit, Butler & O'Connell, 2002). Physical activities develop learning and memory in human beings and animals. Also, an active lifestyle postpones cognitive performance deterioration in old age or prevents neuro-destructive diseases (Cotman, Berchtold & Christie, 2007). Exercise makes numerous alterations in the brain, the most important of which is brain growth and revival (Cotman et al., 2007). Memory is a process in which knowledge is coded, stored and remembered. Learning is related to behavioral approaches and memory is related to cognitive ap-

proaches (López, Zamarrón & Fernández, 2000). Different types of memory are recognized, every one of which preform with a specific part of the brain (Robertson, 2002). Memory is categorized into four types regarding time. Short-term memory: it takes only a few seconds. Working memory: it takes a few seconds to a couple of hours. Long-term memory: it takes hours to months. Long-lasting memory (permanent): it takes months and even for the rest of one's life. Short-term memory is considered as a temporary storage system that can hold a small amount of information (Ahlemeyer, Beier, Semkova, Schaper & Krieglstein, 2003). Long-term memory is a storage system to store information for a longer time or forever without any capacity limitations; but it is difficult to transfer information into this memory. Practice transfers information from short-term memory to long-term memory

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(Robertson, 2002). Short-term memory is important for all people at any age for learning and daily business. This type of memory is especially important for adults who get involved in learning and professional issues simultaneously (Lakka et al., 2003). Sometimes adults complain about their ability to remember names, faces, and important life events (Berchtold, Castello & Cotman, 2010). Various reports state cognitive performance deterioration, especially that of memory in the adult years (Sibley & Beilock, 2007). Taking part in regular sport activities has beneficial effects on individuals' health (Borrego et al., 2015; Duggan et al., 2004; López et al., 2014, 2017, 2018). Different researches show that those who perform physical exercise grow better brain cells. Recent studies reveal that brain responds greatly to exercise and changes occur in molecular, cellular and anatomic levels. More importantly, these changes occur in areas of brain that are more important for learning, memory and cognitive performance (Filit et al., 2002). The molecule that has been identified as the important one for nerve cell health, learning and memory helps the growth of Brain-Derived Neurotropic factor (BDNF). This growth factor, in fact, improves a specter of neurons and regulates the flexibility of nerve cells (Tyler, Alonso, Bramham & Pozzo-Miller, 2002). Regular participation in physical activities brings about different benefits for mental health. Empirical evidence and meta-analysis reviews prove this benefit in connection with numerous psychological variables (cognition, sleep, stress). Although benefits of physical activities for mental health are relatively clear, the responsible mechanism is not identified yet.

Cardiorespiratory fitness suggests that aerobic fitness acts as a medium for this positive effect (Duggan et al., 2004). According to a statistical meta-analysis, randomized clinical trials related to sport accompany significant improvements in cognitive performance, information processing speed, memory and motor performance (Colcombe & Kramer, 2003). Although physical readiness affects cognitive-neurologic performance in cross sectional studies, more aerobic readiness accompanies less cognitive performance (Etnier et al., 1997) and Blumental et al. (1998) did not witness a great difference in remembering the memory during physical exercise (Leff et al., 2002). Adlard & Cotman (2004) showed that a voluntary exercise is a simple tool to maintain and revive levels of BDNF in brain without using a drug. Sibley et al. indicated in a study that severe exercise has the most benefit for healthy adults, especially those with lower cognitive performance; also, they proved that exercise does not affect different individuals similarly (Sibley & Beilock, 2007). Huang et al. (2013) state that aerobic exercise increases BDNF in healthy men and women (Huang, Larsen, Ried-Larsen, Møller & Andersen, 2014). Zoladz et al. (2008) also, observed an increase in levels of BDNF in healthy young males after a set of endurance exercise. Yet, Williams and Ferris (2012) do not

approve of this. Active people have better cognitive performance in compare with their inactive counterparts and exercise prevents Alzheimer's disease in future.

But randomized clinical trials present contradictory results; some of them show cognitive performance improvement and some present opposite results (Williams, 2012). Some studies show that excessive and aerobic exercise improves short-term and long-term memory (Etnier et al., 1997). Also, some other studies prove that exercise improves memory at old age (Rahe et al., 2015). According to previous studies, it seems sport exercise may affect memory, but the effects are functions of type, excess and duration of sport exercise (Filit et al., 2002). Since, the results of these studies are contradictory, and few studies are performed on human cases; it seems necessary to perform a study to measure the type and excess of exercise. Therefore, this study is performed to investigate the effect of aerobic, strength and aerobic-strength exercise on the memory of women.

## Methods

### Participants

The participants were middle-aged female adults (ages 36-55 years, mean=45.35, SD = 5.51), of Orumieh (Iran) with no previous experience of doing any exercise during the past year, and no medical recommendations forbidding them from doing exercise. Health questionnaires and consent forms were filled by volunteers, so a group of 60 participants with no previous experience of alcohol or smoking or diets or drugs or diabetes and heart diseases were selected using convenience sampling method.

### Instruments

Measurement of short-term memory was done using digit span memory test. Reliability coefficient of the test was determined at an acceptable level ( $r=0.81$ ) (Goekint et al., 2010). In order to account for reliability of the test it was taken again with 13 elderly women. Internal correlation coefficient (ICC) for Digit span memory test was measures as  $r=0.777$ . Before taking the test full explanation was presented for participants and after making sure about their understanding of the test thoroughly the test began. Digital span memory test was performed in a quiet and vacant place. In this test different numbers, like 9-digit numbers, are shown to the participants. Every number is shown for as long as 1 second; and after a 0.5-second break, the next digit is displayed. In the end the participant is required to repeat the numbers in a sequence or as a number consisting of all the digits (like 430065789) (Goekint et al., 2010).

**Procedures**

Participants were divided into 4 groups accidentally. The first group (aerobic) practiced for 8 weeks according to a 3-times-a-week plan. Every time they practiced for 45-60 minutes using treadmill. The second group (strength) practiced for 8 weeks; three times week for 60 minutes. Their exercise included a strength plan using Technogym body building equipment made in Italy and the third group practiced according to a combined plan for eight weeks, three times a week and every time 60 minutes. There were no alterations for the fourth group and they were banned from taking part in any physical activities out of the research plan. Sort-term memory of all the 60 participants were measured and recorded before and after the study using digital span memory test. Aerobic group’s plan included three-times a week and every time 45-60 minute of fast walking or slow running with 60-75 percent of heart rate recorded on a tape. To measure this heart rate, Karvonen heart rate calculator based on age was used (Touleme, Oauglas & Hiller, 1998).

Maximal heart rate= (220-age)

Stored maximal heart rate= (maximal heart rate- resting time heart rate) \* desired excess

The strength group practiced for eight weeks, three times each week, including 60 minutes of working with body building equipment. Also, they had a separate plan based on major muscles (biceps and Triceps and chest and back muscles and lower body muscles). The excess of the strength plan was 40-60 percent of 1RM. They started with 40 percent of 1RM and they added 5 percent every two weeks. The desired

excess is obtained using an estimated method of maximal repetition (Leutholtz, & Ripoll, 2011). 1RM=100%- (repetition number \* 2.5)

Aerobic-strength group took part in a combined plan for 60 minutes every time. This included 15 minutes of warming up, 35 minutes of combined plan including aerobic movements and practicing with dumbbell and wood and TRX and 10 minutes of cooling down.

**Statistical Analysis**

In the descriptive statistics range, standard deviation is used. The statistical tests of Kolmogorov-Smirnov were used to determine if the data was normal; dependent t-test and covariance analysis were used for data analysis at a significance level of  $\alpha = 0.05$ . The software used was SPSS 24.0.

**Results**

According to the table below, the results of the dependent T-test (T(14)= -5.870) showed that there is a meaningful difference between pre-test and post-test scores of the aerobics group (p=0.001). So, aerobic exercise has a meaningful effect on short-term memory. Also, the table indicates that (t(14)= -4.141) there is a meaningful difference between pre-test and post-test scores of the strength group (p=0.001). So, strength exercise affects short term memory; that means, strength exercise improved the memory. Furthermore, the results from the table for aerobic–strength group indicate that (t(14)= -0.878) there is a meaningful relationship between pre-test and post-test scores of aerobic–strength group (p-0.029). Thus, aerobic–strength exercise improved memory.

**Table 1.** The results of T-dependent test in three groups of aerobic, anaerobic and aerobic-strength.

T-dependent test	Dual differences					T	df	Sig
	Mean	Standard deviation	Standard error	95% confidence interval				
				The least	The most			
Short-term memory (aerobic)	-1.067	0.704	0.182	-1.456	-0.677	-5.870	14	0.000
Short-term memory (strength)	-1.133	1.060	0.274	-1.720	0.546	-4.141	14	0.001
Short-term memory (aerobic-strength)	-0.467	0.743	0.192	-0.878	-0.055	-2.432	14	0.029

Eight weeks of aerobic, strength and aerobic-strength exercise affected short term memory of adult women differently. To evaluate this hypothesis, covariance test was used.

Since the assumptions of covariance are observed, this test was practiced to study the effect of grouping on short-term memory. The results of this test are presented in Table 2:

**Table 2.** The result of covariance test regarding women's short-term memory.

Source	Total sum of squares	Degrees of freedom	Average of Squares	F	Sig	Effect degree
Pre-test	97.176	1	97.176	136.261	0.000	0.712
Group	16.995	3	5.665	7.944	0.000	0.302
Error	39.224	55	0.713			

According to the statistics of covariance test (7.994) with a freedom degree of (3) and the significance level of (0.000) and comparison with alpha (0.05) we come to conclusion; the null hypothesis suggesting lack of aerobic, strength and aerobic-strength pretties effect on the memory of the women is rejected and research hypothesis is confirmed ( $p < 0.05$ ).

Hence, the results from table 4.8 suggest that considering pre-test points as covariant variable, the difference between the three groups of aerobic, strength and aerobic-strenght is meaningful in  $p < 0.05$  level. In other words, a comparison

between moderated average for control group (7.16), aerobic (7.16), strength (8.49) and aerobic-strength (7.97) we may conclude that aerobic and aerobic-strength exercise increase show term memory of women in comparison with the control group. Here the amount of change is 30 percent. In another word, 30 percent of posttest variance is because of learning intervention. In order to compare groups, the follow-up LSD test was performed. The results of this test that compare groups to gather are shown in table 3.

**Table 3.** The results of LSD test to compare groups.

Group I	Group J	Difference average (I-J)	Standard deviation	Meaningful level
Control	Aerobic	0.000	0.31	1.000
	Strength	-1.32	0.32	0.000
	Aerobic-strength	-0.80	0.31	0.012
Aerobic	Strength	-1.32	0.32	0.000
	Aerobic-strength	-0.80	0.31	0.012
Strength	Aerobic-strength	0.52	0.32	0.11

The results of this test suggest that there is a meaningful difference between the strength group and the control group ( $p < 0.01$ ) and there is a meaningful difference between control group and strength-aerobic group ( $p < 0.05$ ); but the difference between this group and aerobic-strength group was not meaningful ( $p > 0.05$ ). Aerobic group has a meaningful difference with strength group ( $p < 0.01$ ) and the difference between aerobic group and strength-aerobic group is meaningful ( $p < 0.05$ ); and the difference between aerobic-strength groups was not meaningful ( $p > 0.05$ ).

## Discussion

The findings from the current study suggest that a period of eight weeks of aerobic, strength and aerobic-strength exercise improve short-term memory performance considerably. Also, strength and aerobic-strength exercises improve women's short-term memory considerably in comparison with control group. There are few studies about the influence of exercise on short term memory. Results show that sport improves cognitive performance and memory by a set of physical and mental changes it creates after a course of exercise sessions (Ferris, Williams & Shen, 2007; Young, 1979). A study prac-

ticed by Dick et al. reveals that physical exercises improve cognitive performance (Dik, Deeg, Visser & Jonker, 2003). Some researchers proved that physical activities are reversely connected with mental deterioration in old people. Another study states that there is a close connection between physical readiness and aerobic capacity and better cognitive and memory performance (Laurin, Verreault, Lindsay, MacPherson & Rockwood, 2001). All these findings are in line with the current study. But, Kirk-Sanchez NJ et al. were unable to find the effect of aerobic exercise on memory and cognitive performance (Kirk & MCGough, 2014). On the contrary, Antunes et al (2015) found out that 6 months of aerobic exercise improves planning, reasoning, executive functions (image setup), attention, spatial memory, verbal memory, learning and information integration capacity (Antunes et al., 2015). Aerobic exercise improves executive performance and volume of some parts of brain (Coclobe et al., 2006). Cellular mechanism of an increase in the volume of some areas of brain (volume increase and connection of temporal and frontal lobe) as a result of endurance exercise increase volume and connection of temporal and frontal lobes by releasing neurotropic factors like BDNF and Insulin-like growth factor )IGF-1) (Padilla, Pérez & Andrés, 2011). Chronic ex-

ercise causes great physiologic changes in brain including more neurogenesis and release of nerve growth factor which in turn affect learning and learning memory capacity (Voss, Nagamatsu, Liu-Ambrose & Kramer, 2011).

## Conclusion

Altogether, the findings state that eight weeks of aerobic, strength, and aerobic-strength exercise improves short-term performance in inactive adult females. So, regarding the beneficial effect of these exercises on the memory in the present study, physical performance can be a proper substitution for drugs that are taken to cure neurological disorders that are related to memory and cognitive performance in adult women who are one of the vulnerable populations because they are on the verge of entering their midlife and they tend to be inactive. One of the results of the current study us that different types of exercise (aerobic, strength and aerobic-strength) can improve memory performance; and numerous

studies show that exercise can improve memory and here we conclude that the improvement in the memory is a function of the type of exercise.

Probably, if individuals exercise according to strength and aerobic-strength method, they will experience an improved memory performance. One of the biggest limitations of this study is the few number of sample groups to do a comparison between aerobic, strength and aerobic-strength exercise. Second limitation is using Digit span memory test. Although this test is standard and easily practicable in human cases, but further studies are suggested for memory measurement. The third limitation is that BDNF was not measured. The next one is that, this study was cross sectional, and it is suggested that in future a longitudinal research be performed. Generally, the findings prove the effect of sport exercise on the improvement of memory performance. Therefore, aerobic, strength and aerobic-strength exercise is suggested to improve memory.

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