

## Aerobic Exercises Improve Blood Flow and Cognitive Functions in Anterior Circulation Ischemic Strokes

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### ABSTRACT

**Background:** Cerebrovascular disorders are the second most common cause of cognitive decline. Aerobic exercises have been proved to improve cognitive functions through producing vascular changes. **Objective:** To assess and explain from physiological point of view the efficacy of aerobic exercise on cognitive changes of stroke patients. **Methods:** Thirty Egyptian patients with stroke in territory of anterior circulation were divided in 2 groups (G1) received a routine physiotherapy program and (G2) performed aerobic exercise in addition to routine program. We compared between the 2 groups using the Adenbrookes's Cognitive Examination-Revised (ACER) for cognitive functional assessment and transcranial Doppler for cerebral blood flow measurements. **Results:** Comparison between the 2 groups showed a statistically significant difference in post-treatment ACER ( $P=0.017$ ). Also we found an increase in mean flow velocity (MFV) in middle cerebral artery in (G2) compared to (G1) ( $P=0.049$ ). A significant positive correlation was found between increased MFV in right MCA and improvement of ACER ( $r=0.62$ ,  $p=0.0136$ ) but not in left MCA ( $r=0.4$ ,  $P=0.14$ ). **Conclusion:** The current study showed positive effect of aerobic exercise on cognitive functions through significant increase in mean flow velocity of middle cerebral artery in patients with ischemic stroke in the territory of anterior circulation. [Egypt J Neurol Psychiat Neurosurg. 2012; 49(4): 305-308]

**Key Words:** Aerobic exercise. Cognitive functions. Stroke. Transcranial Doppler.

### INTRODUCTION

Vascular diseases are the second most common cause of cognitive decline and dementia especially strokes that may have a severe effect on cognition.<sup>1</sup> Cognitive impairment in stroke patients is associated with short and long term poorer outcome and have a profound effect on physical rehabilitation in such patients. Attention and decision making are necessary for ambulation and activity of daily living<sup>2</sup>.

Aerobic exercise refers to exercise that improves oxygen consumption by the body. It is the type of activity that uses large muscle groups. Its performance is in a continuous and rhythmic way with a main goal to make the heart and lungs work harder than they do when the person at rest<sup>3,4</sup>.

Role of aerobic exercise have been proved to improve cognitive functions through different mechanisms. Aerobic exercise produces vascular changes, including an increase in oxygen saturation, promotes angiogenesis, and increases cerebral blood flow (CBF) in areas related to cognitive function.<sup>3</sup>

Transcranial Doppler (TCD) is a noninvasive, inexpensive, safe, and reliable diagnostic tool. It can be used to evaluate cerebrovascular tree in patients with neurovascular disorders<sup>5</sup> TCD is a useful tool in the assessment of cerebral hemodynamics in relation to cognitive functions<sup>6</sup>.

The aim of this study is to determine the efficacy of aerobic exercise on cognitive functions in stroke patients and to explain this effect through the changes in vascular supply of the brain.

### SUBJECTS AND METHODS

In the current study we included thirty Egyptian stroke patients, all proved to have some degree of cognitive impairment measured by Adenbrookes's Cognitive Examination- Revised (ACER)<sup>7</sup> with function of less than 82. We included educated patients of both sex, age ranged from 40-60 with a single ischemic stroke in the territory of the anterior circulation, duration of illness from three to eighteen months who were medically and psychologically stable and of adequate cardiac function. We excluded patients with multiple strokes, with previous cognitive, mental, visual, auditory, neurological problems and also cardiac diseases.

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The study population was divided into two equal groups of fifteen patients each; group 1 (G1) (considered as the control group) were treated by a designed physiotherapy program. This program was applied for 25-30 minute per session, three times per week, day after day for successive eight weeks. This program consisted of stretching exercises, facilitation for weak muscles, strengthening exercise, postural control and balance, functional training and gait training. Group 2 (G2) were treated by the same designed physiotherapy program for "25-30" min. followed by a rest period for about 10-15 min, then aerobic exercise was done on a bicycle for 40 to 45 min (according to ability of each patient), three times per week for eight weeks.

All patients in both groups were subjected to reassessment of cognitive functions using ACER after eight weeks. The affected middle cerebral artery flow parameters (peak systolic velocity, mean blood flow velocity, pulsatility and resistivity indices) were measured at baseline before and eight weeks after physiotherapy program in both groups. Cerebral blood flow measurement was performed in the Neurovascular laboratory, Department of Neurology at Cairo University hospitals using 4 MHZ Multi frequency Transcranial Doppler probe (Multi-Dop® T digital model 2007, manufactured by Compumedics Germany GmbH, Singen – The DWL® Doppler Company).

**Statistical Analysis**

The obtained data were collected and statistically analyzed using the arithmetic mean and their standard deviation. Paired t-test was used for comparison of means pre and post treatment within each group. Unpaired t-test for comparison of means pre and post treatment of two independent groups. Pearson rank correlation test to correlate between variables post-treatment in study group<sup>8</sup>.

**Table 1.** Age and body mass index (BMI) in both groups.

Variant	G1	G2	P-value
Age (years)	49.67± 6.98	48.4± 6.39	0.608
Body mass index (Kg/m <sup>2</sup> )	25.26±1.84	25.75 ± 2.16	0.51

**Table 2.** ACER score and transcranial Doppler finding in MCA of affected territory (peak systolic velocity (PSV), mean flow velocity (MFV), pulsatility index (PI), resistivity index (RI)).

Variant	G1	G2	P-value
ACER score	74.47±5.58	73.47±6.2	
PSV (cm/sec)	74.13±10.95	69.87±17.7	
MFV (cm/sec)	46.13±9.15	44.13±12.01	P>0.05
PI	0.9527±0.28	0.9±0.17	
RI	0.59±0.09	0.57±0.07	

**RESULTS**

There was no statistical significant difference (P>0.05) between both groups regarding baseline characteristics including age, gender, Body mass index and pretreatment ACER score and transcranial Doppler flow parameters as shown in Table (1, 2).

Comparison of the Addenbrooke’s Cognitive Examination Revised (ACER) total score post-treatment in (G1) and (G2) showed a statistically significant difference with increased values in the (G2) group; 75.93±4.9 and 81.07±6.16 respectively (p= 0.017). The mean values of the sub test domains (attention, memory, verbal fluency, language and visuospatial ability variables) post treatment in (G1) were 15.47±1.96, 19.07±2.6, 2±1.25, 25.53±1.13 and 13.87±1.4 respectively, in (G2) were 16.87±1.5, 21.27±3.15, 2.6±1.1, 25.27±1.4 and 15.07±1.28 respectively. Comparison of the mean value of each domain in (G1) with the corresponding mean value in (G2) revealed a significant increase in all domains in G2 (p<0.05) except for verbal fluency and language domains (p=0.18 and 0.58 respectively).

Post-treatment comparison of middle cerebral flow parameters of both groups showed a statistically significant difference (P<0.05) with the (G2) showing improvement in all TCD parameters in the territory of the affected MCA as shown in Table (3).

Pearson rank correlations (r) between the post treatment changes in total score of ACER test and mean velocity in right and left MCA in (G2) were 0.62 and 0.4 respectively. The results indicated that there was a significant positive correlation between improvements in total score of ACER test and increase in mean velocity in right MCA in (G2) (P=0.0136). There was no significant correlation between changes in total score of ACER test and changes in mean velocity in left MCA in (G2).

**Table 3.** The mean values of different variables of blood flow in the affected middle cerebral artery (MCA) post-treatment in G1 and G2.

Variables	Post-treatment		P-value
	Mean±SD in G1	Mean±SD in G2	
Peak systolic velocity (cm/sec)	67.47±19.04	81.77±18.8	0.048*
Mean flow velocity (MFV) (cm/sec)	43.07±12.2	52.47±12.78	0.049*
Pulsatility index (PI)	0.93±0.17	0.76±0.12	0.004**
Resistivity index (RI)	0.61±0.08	0.53±0.08	0.011*

\*Significant at  $p < 0.05$  \*\* Significant at  $p < 0.01$

## DISCUSSION

The current study showed that aerobic exercises significantly improve the cognitive functions and cerebral blood flow in patients with ischemic strokes in the territory of anterior circulation. Statistically significant differences in ACER test and cerebral blood flow parameters measured by TCD in both MCA was found between both groups with increased improvement in patients who were added aerobic exercise to their routine physiotherapy program.

Almost all the patients at the onset of stroke showed different degrees of cognitive affection. The maximum duration was 18 months to avoid the delayed cognitive decline that may occur after vascular insult due to other causes (e.g.: depression) and not as a direct cause of stroke.<sup>9,10</sup> Many studies have previously proved the beneficial effect of aerobic exercises on cognitive functions as we showed in our study attributing this improvement to many theories; cerebral tissue oxygenation, blood flow velocity and cerebral metabolism and homeostasis which in turn improve the speed of information processing, motor learning, implicit memory and executive function<sup>10-13</sup>. It was proved also that a biochemical response occurs within the body and the brain of animals which participate in exercise. Exercise increases serum calcium levels, which can then be transported to the brain to activate the rate limiting enzyme for catecholamine (dopamine and norepinephrine) synthesis. Both of them are neurotransmitters that have significant involvement in human cognitive performance<sup>14</sup>. A study conducted by Ploughman et al.<sup>15</sup> contradicted our results but their negative results may be attributed to the small sample size and the short duration of the physical therapy intervention. Masley et al.<sup>11</sup> proved that improvement in cognitive flexibility was proportional to the degree of exercise as he assumed that sustained aerobic exercise (over months) is required for cognitive improvement that is why we separated our primary assessment and

reevaluation by eight weeks. Improvement in all domains of ACER test except language and verbal functions can be explained by the higher positive correlation we found between increased flow in right MCA and total ACER score but not left MCA as the right hemisphere concerned with the visuospatial and attention functions while the left hemisphere concerned with verbal and language abilities<sup>16</sup>.

The study also showed a significant improvement in flow parameters (MFV, PI, RI) in both MCA (affected and unaffected) in the study group (G2) compared to the (G1) control group. The improvement may be attributed to the physiological effect of aerobic exercise on body and brain as it increases oxygen consumption, reduces blood pressure and resting heart rate, strengths and enlarges the heart muscle which reflects on its pumping efficiency leading to increase in global and regional cerebral blood flow. In addition aerobic exercise was proved to promote angiogenesis and increase in capillary density<sup>17,18</sup>. The study protocol utilized moderate exercise because it was proved that harder aerobic exercises can have detrimental effect on cerebral blood flow as it leads to decrease of the arterial PCO<sub>2</sub> secondary to hyperventilation<sup>19</sup>.

In **conclusion** we found that moderate aerobic exercise added to the usual physiotherapy program in post-stroke patients improved their cognitive functions through increasing cerebral blood flow to the brain. Mean flow velocity can be used as a physiological biomarker for improvement of cognitive functions in such patients.

[Disclosure: Authors report no conflict of interest]

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### الملخص العربي

يعانى ثلث مرضى السكتة الدماغية من خلل إدراكي الذي يعيق الشفاء، تهدف هذه الدراسة إلى بحث تأثير التمرينات الهوائية على الوظائف الإدراكية لدى مرضى السكتة الدماغية. ثلاثون مريضاً بالسكتة الدماغية تراوحت أعمارهم بين 40-60 عاماً شاركوا في هذه الدراسة، تم اختيارهم من الجنسين وقسموا إلى مجموعتين متساويتين مجموعته ضابطه "ج1" ومجموعه دراسة "ج2". وقد خضعت المجموعة الضابطة إلى برنامج علاج طبيعي مقترح وخضعت مجموعته الدراسة إلى نفس البرنامج العلاجي بالإضافة إلى تمرينات هوائية باستخدام العجلة الثابتة لمدة 40 - 45 دقيقة، ثلاث جلسات في الأسبوع لمدة شهرين. قيم الإدراك قبل وبعد العلاج عملياً بواسطة اختبار "ادنبروك المعدل"، فسيولوجياً باستخدام جهاز الدوبلر عبر الجمجمة لقياس سرعة تدفق الدم عبر الشريان الأوسط الدماغى للناحييتين المتضررة وغير المتضررة، وقد اظهرت النتائج وجود تحسن ذو دلالة إحصائية في مجموعته الدراسة لكل من اختبار "ادنبروك المعدل" ومتوسط تدفق الدم في الشريان الأوسط الدماغى للناحييتين (الناحية اليمنى اكبر من الناحية اليسرى)، قد تماشت النتائج الفسيولوجية مع النتائج العملية للاختبار ومن هنا يتضح أن التمرينات الهوائية لها تأثير إيجابي في تحسن الوظائف الإدراكية لدى مرضى السكتة الدماغية.