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IMPROVEMENT IN THE FACE/NAME ASSOCIATION PERFORMANCE AFTER THREE MONTHS OF PHYSICAL TRAINING IN ELDERLY WOMEN

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Several lines of evidence suggest that physical exercise not only influences the development of muscles, cardiovascular and respiratory systems, but also exerts a significant influence on the central nervous system. We examined the influence of strength and endurance training on cognitive performance in 33 healthy elderly volunteers (women, mean age 63.5 ±4.5 yr) over a 3-month period of supervised training program. A control group consisted of 8 age-matched (mean age 66.3 ±4.6) healthy volunteers who did not participate in any exercise training program. To evaluate the cognitive performance in our subjects we used two tests: face/name association test and Stroop test. The tests were applied shortly before and immediately after the training program. In the experimental group, a significant improvement in the association test performance, on average, from 71.6 ±7.3% to 79.7 ±7.2% ($P<0.0001$) was observed over the 3-month training period. There were no changes in the Stroop test results over the same time. Likewise, there were no changes in the control groups. Our data demonstrate that the training regime that is strictly followed over a relatively short period of time may improve the performance in associative memory tasks in elderly subjects. The study supports the notion that physical exercise influences cognitive performance and extend this notion to be valid for healthy elderly subjects.

Key words: *cognition, declarative memory, physical training, elderly women, Stroop test, face/name association*

INTRODUCTION

The insufficient level of systematic physical activity is one of the main causes of premature deaths in many countries. Poland belongs to the group of countries where the level of physical activity is particularly low. Over 70% of adult men and women admit that they their lifestyle is sedentary, and only 6-10% of the Polish population exercises regularly (1). The studies conducted in many different countries unambiguously demonstrate that lifestyle incorporating regular exercise correlates with good health, higher quality of life, and longevity. Insufficient exercise, in turn, is the risk factor for many chronic diseases including arteriosclerosis, stroke, coronary diseases, diabetes, and even tumors (2-5). Systematic physical exercise is associated with many beneficial changes (e.g. improved blood lipid profile, permanent and progressive loss of fat mass with a simultaneous increase in muscular mass, normalized blood pressure and heart rate) leading to the increased overall physiological efficiency of the organism (6-8). People exercising regularly have greater mobility of the chest and increased strength of the respiratory muscles resulting in an increase in vital lung capacity (9, 10). Furthermore, physical activity has a positive influence on the skeletal system reducing, e.g., the risk of osteoporosis (11).

Several lines of evidence indicate that physical activity exerts positive influence on the central nervous system functions and that it can slow down the processes associated with brain aging (12-14). At the psychological level, different forms of systematic physical activity may lead to increased self-esteem, mood, well-being, and a decrease in the anxiety and stress levels (4, 14, 15). Regular physical exercise contributes to the development of imagination, sustained attention, shortens the time of reaction, and leads to the improvement in decision making process (14, 16). In elderly humans, studies employing various exercise programs demonstrated that regular physical exercise helps in long term maintenance of several cognitive skills (15, 17). Majority of studies focused on the influence of long-term physical training programs on the central nervous system functions. In the current study we examined the influence of a three-month physical training on the cognitive functions in elderly women.

MATERIAL AND METHODS

The study was conducted in accordance with the Declaration of Helsinki for human studies and the study protocol was approved by a local Ethics Committee.

Forty-one female volunteers were recruited from a local chapter of The Third Age University in Bydgoszcz. Based on medical examination and interview selected women were healthy, did not suffer from any serious chronic condition, were postmenopausal, and did not undergo hormone replacement therapy (18).Volunteers were divided into the experimental (n=33) and control groups (n=8). In the experimental group, the mean age was 63.5 ±4.5 yr (range 57-71 yr) and in the control one it was 66.3 ±4.5 yr (range 59-72 yr). There was no statistically significant difference in the age between the two groups. The experimental group took part in a closely supervised training program incorporating both strength and endurance components. The program was continued for three months (from December 2005 to March 2006). The exercise sessions took place three times a week. Each session lasted 45 min. The control group did not participate in any training program.

Two cognitive tests were used: the face/name association test and the Stroop test (18-20). The tests were conducted before the onset of the training program (December) and after its completion (March). All tests were performed between 8:00 am and 12:00 pm. In the acquisition phase of the face/name association test, 50 faces were shown in a sequence on a computer screen. Each face was shown for 4 second and was accompanied by one name displayed underneath. A 10-minute break separated the acquisition phase from the recall phase. During the recall phase the computer screen displayed a face with two names to choose from. The task of a subject was to choose one name that she associated with a displayed face. No time limit was assigned during the recall phase of the experiment. The displayed face was changed for another one after the subject decided what name to choose. The results were recorded as a percentage of faces that were associated with the correct name. The Stroop test consisted of four pages. The first test page contained the names of colors written in two columns in black ink (20 words in each column). The task was to read the names of the colors. The second page contained the rows of cross marks (+) in two columns (20 rows in each column). The rows of cross marks were displayed in different colors. A color of each row was recognized and pronounced by each participant. The third and fourth pages contained the names of colors written in two 20-word columns. An ink color was different than the name of a color. The written name of colors (third page) or the color of the ink (fourth page) were recognized and pronounced by each subject. For each page the time of reading duration was recorded. In the statistical analysis we used the reading time of the last page (recognizing colors not their names) expressed as a percentage of the first page reading time. The middle two test pages served as a control for the ability to read and recognize colors.

Mean ±SD results were presented. A *t*-test was used for statistical analysis of the results. The results within the same group (December tests *vs.* March tests) were compared with a two-tailed paired *t*-test. To analyze the results between the groups (the experimental vs. control group) we used a two-tailed heteroscedastic *t*-test.

RESULTS

There were no significant differences between the experimental and control groups in the tests conducted before the start of the exercise program (December). The mean result in the Stroop test was 244.6 ±62.0% and 279.0 ± 6.3% in the experimental group and control groups, respectively. After the 3-month time (March) no changes were observed in the Stroop test results. The respective results were 247.1 ±56.5% and 284.1 ±65.1% in the experimental and control groups (*Fig. 1*). Individual changes in the relative reading time of the last page after the 3-month training program are presented in *Fig. 2*. In 18 of the 33 women the reading time decreased (by 0.2-33.3%) and in another 15 increased (by 3.1-64.7%), overall remaining statistically unchanged. Likewise, there were insignificant fluctuations of the reading time in the control group.

Similarly to the Stroop test, there were inappreciable differences in the mean results of the face/name association test between the experimental and control groups before the training program (December); 71.6 ±7.3% and 69.8 ±10.1%, respectively (*Fig. 3*). After the exercise time, the experimental group's face/name

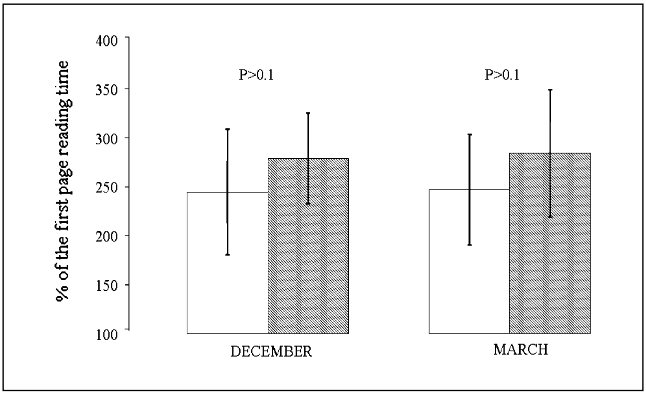

Fig. 1. Mean results of the Stroop test in the experimental-exercise (open bars) and control-no exercise (dotted bars) groups in December and March.

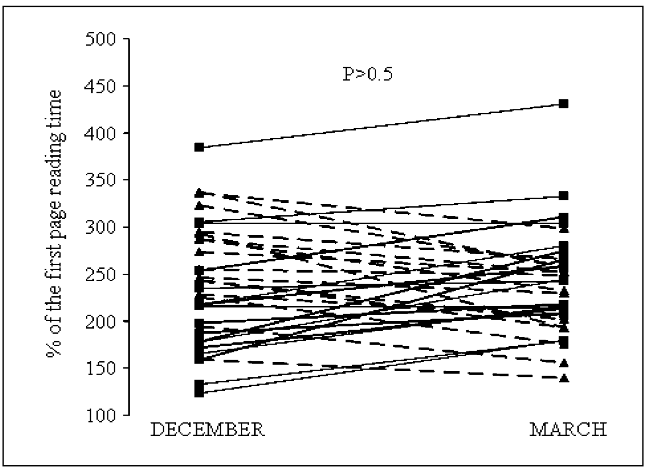

Fig. 2. Individual relative values of the Stroop test in the experimental group. Each subject's results from December to March (before and after the exercise program) are connected by a line. Solid lines depict subjects who faired better on the test and dashed lines those who faired worse in March.

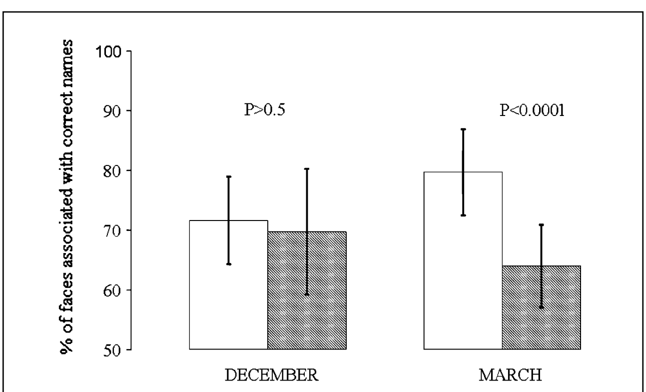

Fig. 3. Mean results of the face/name association test in the experimental-exercise (open bars) and control-no exercise (dotted bars) groups in December and March.

association result averaged 79.7 ±7.2%. This score was significantly different from that before exercise in the same group and also from that in the control

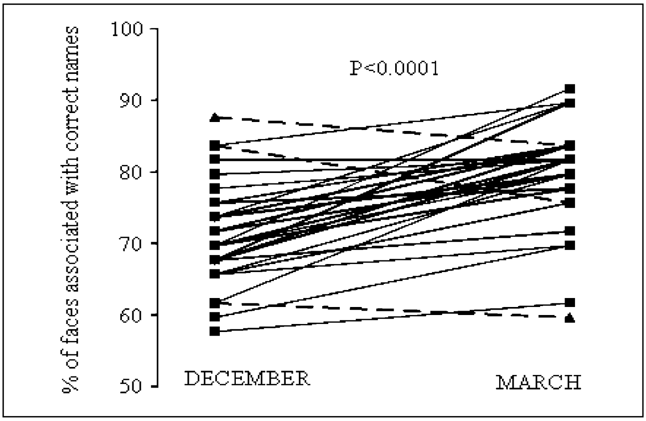

Fig. 4. Individual relative values of the face/name association test in the experimental group. Each subject's results from December to March (before and after the exercise program) are connected by a line. Solid lines depict subjects who faired better on the test and dashed lines those who faired worse in March.

group (P<0.001). In the experimental group, 28 women improved their score (by 2.5-32.4%), the score remained unchanged in 2 and decreased (by 3.2-9.5%) in 3 women (*Fig. 4*). In this test there were no significant differences noted between December and March in the control group.

DISCUSSION

The main finding of this study is that a 3-month period of physical training of moderate intensity (incorporating both strength and endurance components) improved one of the two cognitive functions studied. The improvement was reflected in a better score in the test evaluating short-term declarative memory as expressed by the face/name association. This type of memory is closely associated with hippocampal activity (21). The improvement was observed only in subjects participating in the supervised exercise program. In contrast, change in the face/name association score was insignificant in the control group, there was, if anything, a tendency for a decrease in this score in the majority of women in that group (5 out of 8) at the end of the study. The control group results allowed excluding the seasonal variation in cognitive performance as an underlying cause for the change in the test score observed in the experimental group.

The exercise program did not affect the results of the Stroop test, which might have to do with a relatively short period of exercise program and/or with the complexity of factors which influence the final test results. The time measure used in the Stroop test to asses the color/word recognition is a result of complex cognitive processes taking place in several discrete areas of cerebral cortex. The subject's abilities to focus on the task and to control automatic reactions substantially factor in the results. These abilities are strongly associated with the activity of prefrontal and anterior cingulate cortical areas (22).

In the past decade, several reports demonstrated beneficial effects of physical activity on human brain function, including the improvement in cognitive function. Currently, the physiological mechanisms underlying such influence are not fully understood. The improvement is rarely directly related to a specific type of motor activity or to modulations in the cardiovascular or respiratory systems. Neural changes resulting from increased physical activity seem a result of complex hormonal interactions inducing proliferation of neurons and dendritic arborization, synaptogenesis, and increasing density of synaptic spikes (15, 23, 24).

A 3-month period of physical training applied in our study was a relatively short one. The majority of previous studies in humans focused on half a year or longer periods of physical activity (25, 26). Studies employing shorter periods show negligible influence of physical exercise on cognitive function (27). The positive influence of a short training program in the current study suggests the existence of high plasticity of cortical areas associated with short-term memory (hippocampus) even in older subjects. Interestingly, cognitive improvement was present in postmenopausal women who did not use hormonal replacement therapy. This observation is at variance with studies that suggest estrogens as key for physical exercise to exert influence on the central nervous system in females (15, 28).

The results of this study pertain to cognitive changes developing under the influence of physical activity in healthy, elderly women. They confirm therapeutic benefits of physical activity. In this respect, physical activity may be particularly important for older subjects who frequently experience a gradual decline in cognitive function related to degenerative changes in the brain. Thus, increased physical activity may contribute to attenuation of such changes. Systematic physical exercise may be important not only for maintaining the quality of life in healthy subjects but for the control of neuropathological changes in mood disorders, depression, and ischemia (12, 14, 29-31).

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