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THE COGNITIVE DIFFERENCE BETWEEN STUDENT GROUPS WITH HIGH AND LOW LEVEL OF PHYSICAL ACTIVITY

RÓŻNICE W POZIOMIE ZDOLNOŚCI POZNAWCZYCH POMIĘDZY GRUPAMI MŁODZIEŻY O WYSOKIM I NISKIM POZIOMIE AKTYWNOŚCI FIZYCZNEJ

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S u m m a r y

We examined the cognitive performance in two groups of young adults differentiated by level of their daily physical activity: high intensity group (HI, 43 male, aged 21.8 ±1.14) and low intensity group (LI, 25 male, aged 21.52 ±1.5). To evaluate the cognitive performance in the two groups we used face/name association test and Stroop test. In the face/name association test we observed statistically significant ($p<0.005$) differences between HI and LI groups. There were no statistical significant differences in the Stroop test results.

S t r e s z c z e n i e

Celem pracy było zbadanie poziomu zdolności poznawczych w grupie młodzieży o wysokim (grupa HI, 43 mężczyzn, wiek 21,8±1,14) i niskim (grupa LI, 25 mężczyzn, wiek 21,52±1,5) poziomie dziennej aktywności fizycznej. Do określenia poziomu zdolności poznawczych w obydwu grupach użyto testu kojarzenia twarz/imię oraz testu Stroopa. W teście kojarzenia twarz/imię zaobserwowano istotną statystycznie różnicę pomiędzy grupą HI w porównaniu z grupą LI ($p< 0,005$). W przeprowadzonych badaniach nie zaobserwowano istotnych statystycznie różnić w wynikach uzyskanych przez obydwie grupy w teście Stroopa.

Key words: cognition, declarative memory, physical training, face/name association test, Stroop test
Słowa kluczowe: zdolności poznawcze, pamięć deklaratywna, aktywność fizyczna, test kojarzenie twarz/imię, test Stroopa

INTRODUCTION

Several lines of evidence indicate that regular physical activity exerts beneficial influence on the general well-being and fitness levels in humans. In particular, the positive effects are observed in the physiological parameters of locomotor, cardiovascular and respiratory systems. Over the last decade, research conducted in several laboratories have clearly demonstrated that the increased levels of physical activity have beneficial influence on several aspects of central nervous system (CNS) function. Significant

improvements were observed in cognitive processes such as memory, learning or attention span under the influence of increased physical activity regimes [1, 2, 3, 4].

Majority of research on effort in humans were directed towards representatives of elderly population. Importantly, in these age groups increased levels of physical activity may be a limiting factor for age-related cognitive decline [2, 3, 5, 6, 7, 8].

Relatively limited number of research addresses the problem of physical activity and CNS function in younger population [9, 10, 11]. In animal models it was demonstrated that beneficial influence of exercise on cognitive function was age-independent. In both younger and older animals it was observed that increase in locomotor activity resulted in intensification of neurogenesis, increase in synaptic plasticity and in expression of genes encoding neurotrophic factors. Interestingly, the effect on proliferation of precursors and survival of new neuronal cells was stronger in younger animals despite already relatively high level of cellular proliferation and survival in this age group [12, 13, 14].

In the current study, in order to further elucidate the association of physical activity with cognitive function, we are assessing the cognitive skill level in two groups of college-aged individuals differentiated by level of daily physical activity.

MATERIAL AND METHODS

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

Two groups of volunteers were recruited from the local university (Kazimierz Wielki University in Bydgoszcz). First group (high intensity of physical activity - HI) consisted of 43 male students aged 21.8 ±1.14 from the Faculty of Physical Education. The low intensity of physical activity group of students (LI) contained 25 male students aged 21.52 ±1.5 from the Faculty of Mathematics and Biological Sciences. Members of the HI group regularly engaged in weekly schedule of at least 9 hours of supervised intense physical activity (including soccer, competitive swimming, Nordic walking, volleyball, track athletics). Students from LI group participated in 1.5 hours of supervised low intensity physical activity (swimming, team games) weekly. Some of the students from this group reported participation in unsupervised physical activity (biking, amateur soccer). However, in no instance the total time of this unsupervised activity exceeded 3 hours per week. (Tab. 1).

Table I. *The characteristics of experimental groups*
Tabela I. *Charakterystyka grup badawczych*

	Gender (Płeć)	**n**	**Age (Wiek)**	**Weekly hours of supervised physical activity (Tygodniowa liczba godzin aktywności fizycznej)**	**Types of physical activity (Rodzaj aktywności fizycznej)**
Hight intensity of physical activity group (Grupa o wysokim poziomie aktywności fizycznej)	male (mężczyźni)	43	21.8 ± 1.14 (range: 21-25)	9	football (piłka nożna) volleyball (siatkówka) basketball (koszykówka) swimming (pływanie) nordic walking track athletics (lekka atletyka)
Low intensity of physical activity group (Grupa o niskim poziomie aktywności fizycznej)	male (mężczyźni)	25	21.52 ± 1.5 (range: 21-25)	1.5	swimming (pływanie) team geames (gry zespołowe)

The assessment of cognitive skills was performed by two tests: name/face association test and Stroop test [15, 16, 17]. The detailed experimental protocols for these tests were described previously [8]. In the acquisition phase of name/face association test subjects were exposed to 100 faces associated with a single name on a computer screen. Each face/name pair was presented for 2 seconds. After 10 min from the end of acquisition phase the retrieval phase began. During this phase test subjects were presented with the same faces as in acquisition phase but each face was associated with two names, one of which was the same name as in acquisition phase. The task of the subject was to indicate the latter name with no time limitations imposed by the protocol. The percent of correctly indicated names and the duration of the retrieval phase were monitored for each subject. The Stroop test

contained three plates; the subject was directed to recognize colors of the objects in each plate. The first plate contained three columns of differently colored dots, the second one – rows of popular words (‘when’, ‘above’, ‘over’ etc.) in different colors and the last one – rows of color names written in ink color different than the color described by the word. The time taken by the subject to recognize colors of each object in a given plate was monitored. The time taken to recognize colors in the last plate scored as a percentage of time taken to recognize colors in the first plate was used for comparisons between groups.

All tests were performed during the month of November 2009 between 10:00 am and 14 pm.

Statistical significance of the differences between the two groups was assessed using two-tailed T-Test. The results are presented as means with standard deviation. $p<0.05$ was considered statistically significant.

RESULTS

In the HI group the mean score of name/face association test was 67.83 ± 7.26 %. In the same test the LI group scored 61.00 ± 6.22 % (Fig. 1a and 1b). These scores were different at the statistically significant level with $p < 0.005$. Statistically significant differences were observed also between the two groups in the duration of the retrieval phase of this test. The HI group mean retrieval duration equalled 296.32 ± 90.6 seconds and in the LI group the retrieval duration was 234.01 ± 76.49 seconds (Fig. 1c and 1d).

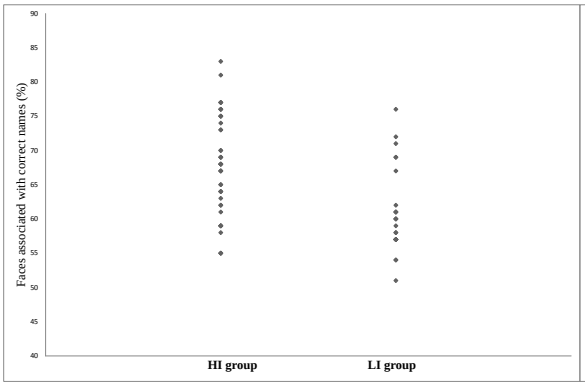

Fig.1a

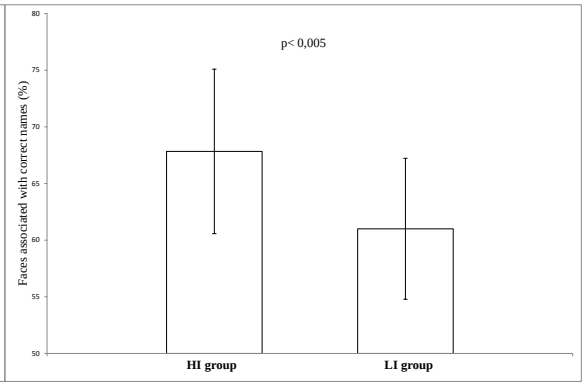

Fig. 1b

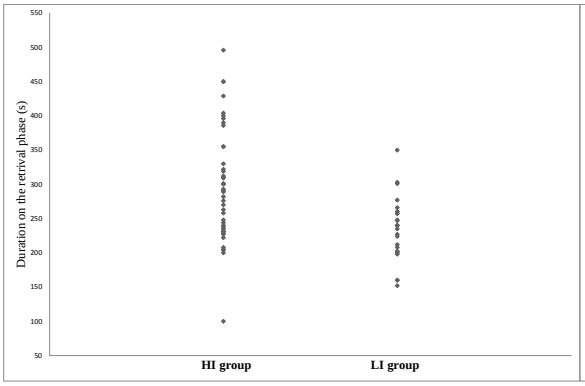

Fig. 1c

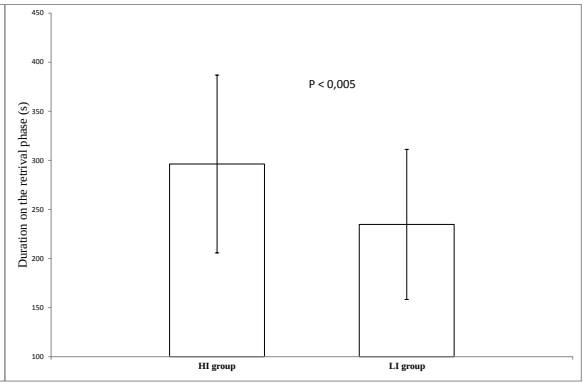

Fig 1d

Fig. 1. *Face/name association test results in high intensity of physical activity (HI) and in low intensity of physical activity (LI) groups. % of correctly associated name-face pairs in the retrieval phase: a) individual data points for all participants from the two groups; b) mean values for each group. Duration of the retrieval phase: c) individual data points for all participants from each of the two groups; d) mean values for each group*

Ryc. 1. *Wyniki testu kojarzenia twarz/imię w grupie o wysokim (HI) i niskim (LI) poziomie aktywności fizycznej. % twarzy poprawnie skojarzonych z imieniem w fazie odtwarzania a) dane indywidualne uzyskane w obydwu grupach; b) średnie wartości uzyskane w obydwu grupach. Czas trwania fazy odtwarzania: c) dane indywidualne uzyskane w obydwu grupach; d) średnie wartości uzyskane w obydwu grupach*

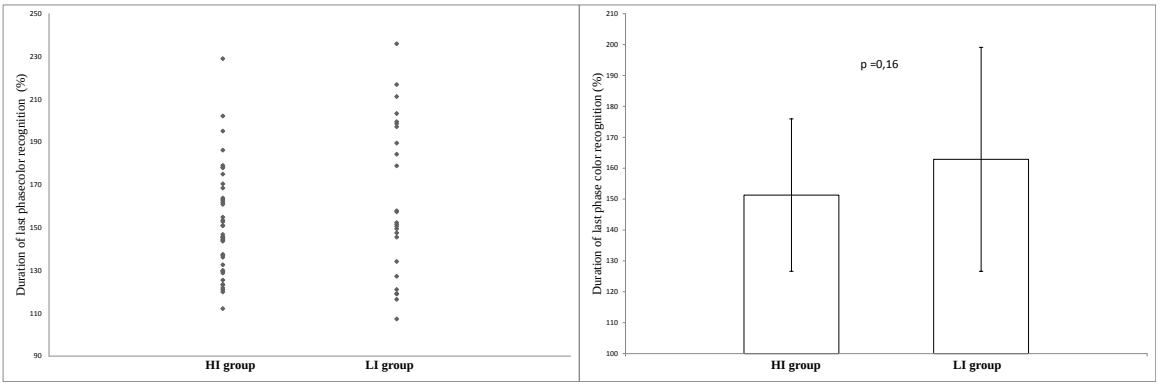

Fig. 2a Fig 2b.

Fig. 2. *Stroop test results in high intensity of physical activity (HI) and in low intensity of physical activity (LI) groups. Duration of color recognition for the last plate, expressed as % of the color recognition duration for the first plate: a) individual data points for all participants from the two groups; b) mean values for each group*

Ryc. 2. *Wyniki testu Stroopa w grupie o wysokim (HI) i niskim (LI) poziomie aktywności fizycznej. Czas odczytania ostatniego arkusza (rozpoznanie koloru) wyrażony jako procent czasu odczytania pierwszego arkusza: a) dane indywidualne uzyskane w obydwu grupach; b) średnie wartości uzyskane w badanych grupach*

In the Stroop test, the HI group reached the mean score of 151.29 ± 24.66 % and the score of LI group equalled 162.88 ± 36.23 % (Fig. 2a and 2b). There was no statistically significant difference between the result of the two groups (p= 0.16).

DISCUSSION

The data presented in this report indicate that there are cognitive differences between male students of Physical Education Faculty and those of Mathematics Faculty of WKU. These differences reached the level of statistical significance with Physical Education Faculty students obtaining better score for accuracy in the face/name association test ($p<0.005$). The results for Stroop test did not show statistically significant difference between the two groups.

These results mirror the differences observed in the elderly women published previously by our laboratory (8). In that study one group of women underwent supervised regime of regular exercise and the other group's physical activity remained at the low level. After the treatment, the former group performance was improved in the face/name association task but not in the Stroop test.

The observed differences in cognitive test performance between the two groups of students may be attributed to the difference in levels of regular physical activity between the two groups. There are many reports, involving both human and animal subjects, indicating regular physical activity as an important factor influencing cognitive skill level [2, 3, 4, 6, 12, 18, 19]. However, one cannot exclude that the factors not controlled for in this study contributed to the final result. For example, the groups might have differed in other lifestyle choices like regularity of sleep hours, diet, sexual activity etc. These factors are also known to influence cognitive efficiency.

It is somewhat surprising that Mathematics Faculty students obtained on average lower scores in the test probing efficiency of short-term declarative memory. These data seem to suggest that level of physical activity may be at least as important factor for development of this cognitive function as strenuous intellectual activity presumed for Mathematics Faculty students. However, at this stage, no definitive conclusions can be drawn.

It is unclear why the Stroop test performance was not differentiated between the two groups. One plausible explanation is related to different brain areas engaged during performance of Stroop test and face/name association test [15, 16, 20, 21, 22]. For the latter, hippocampus is of critical importance. Hippocampal structure was shown to be relatively easily influenced by environmental factors due to the lifetime presence of neuronal stem cell population native to this structure [23, 24]. The Stroop test performance is attributed mainly to the activity of prefrontal cortex lacking significant population of neuronal precursor cells in adult mammalian brain.

At the same time some published reports indicate that higher level of regular physical activity does influence Stroop test performance in a positive way [25]. It is not clear what the source for these

discrepancies in Stroop test results is. In order to resolve this inconsistency detailed analysis of experimental protocols would have to be performed. The differences in physical activity regimes or/and in the Stroop test version used may underlay the observed contradictions. However, it seems safe to state that given the Stroop test results variability the effect of regular physical activity on parameters assessed by face/name association test is robust in various experimental settings.

While the mean accuracy of name/face association was higher in Faculty of Physical Education students, on average the time they used for completion of retrieval phase of this test was longer than the duration of retrieval phase recorded for Mathematics Faculty students. The meaning of this difference is difficult to evaluate, especially due to the fact that most of the processes related to the test completion (face recognition, formation of memory traces) are not consciously controlled [26]. The duration dissimilarity may hint that the observed difference in accuracy score is related not only to the memory-formation processes. It may reflect, for instance, difference in motivation levels between the two groups of students. However, this hypothesis is not consistent with Stroop test result similarity.

Our data strongly indicate the difference in cognitive processes between the two groups of students – one from Faculty of Mathematics and the other from Faculty of Physical Education. The observed differences may be related to different levels of physical activity in the two groups.

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