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MOTOR LEARNING AND MEMORY IN ANIMALS WITH EXPERIMENTALLY INDUCED DEPRESSION (NOTE II)

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ABSTRACT. The effect of physical exercise on motor learning and memory in animals with experimentally induced depression was studied. Depression was induced using the Kelly method (1987), through bilateral olfactory bulbectomy. The control of depression was performed using the tail suspension test (Steru et al. 1985). We used 3 study groups, male rats. A control group (C), one with induced depression (I), and one with induced depression and trained for 28 days (II). The results obtained show a decrease in the learning capacity, without memory changes in group I. In group II we observed an increase in the learning capacity compared to the control group and group I, with a decrease in the memory capacity compared to controls and an increase in the memory capacity compared to group I. Physical exercise is a favorable factor that may contribute to the prevention of learning and memory difficulties in depression.

Keywords: physical exercise, depression, motor learning, memory

REZUMAT. ***Învăţarea motorie şi memoria la animale cu depresie indusă experimental (nota II).*** Am studiat efectul exerciţiului fizic asupra învăţări motorii şi a memoriei la animale cu depresie indusă experimental. Depresie a fost indusă folosind metoda Kelly (1987) prin bulbectomie olfactivă. Controlul depresiei a fost făcut prin testul suspensiei cozii(Steru et al. 1985). În cercetare a fost cuprinse trei loturi, şobolani masculi. Un lot de control (C), un lot cu depresie indusă (I) şi un lot cu depresie indusă şi antrenat la efort timp de 28 de zile (II). Rezultatele obţinute au arătat o scădere a capacităţii de învăţare în grupul I; în privinţa grupului II s-a observat o creştere a capacităţii de învăţare şi a memoriei faţă de grupul I dar o scădere faţă de lotul de control. Exerciţiul fizic este un factor favorabil care poate contribui la prevenirea dificultăţilor în învăţare şi în memorare legate de depresie.

Cuvinte cheie: exerciţiu fizic, depresie, învăţare motorie, memorie

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Introduction

The data on motor behavior changes in animals with experimentally induced depression by olfactory bulbectomy led us to study the influence of depression on motor learning capacity and memory.

Motor learning is defined as the acquisition and maintenance of new motor skills (Foss and Keteyian 1998). The structures specialized in motor learning are in the neocortex – the premotor area and the additional motor area; the basal ganglia and the thalamus; the cerebellum (Foss and Keteyian 1998, Weineck 1995).

Motor learning involves: the reception and selection of information, the central nervous control of afferent pathways, the information processing capacity; the storage of sensory and sensory-motor information in the memory (Weineck 1995).

Objectives

The effect of physical exercise on motor learning and memory in animals with experimentally induced depression was studied.

Material and methods

The studies on male Wistar rats aged 4 months, with a weight of 200-250 g, from the Biobasis of the "Iuliu Haţieganu" University of Medicine and Pharmacy Cluj-Napoca, were carried out in the Experimental Research Laboratory of the Department of Physiology, with the approval of the Bioethics Board.

Groups (n = 10 animals/group)

- group C – control group of males
- group I – males with depression
- group II – males with depression, subjected to the swimming test (one hour daily for 28 days, after day 7 postoperatively)

Depression was induced using the Kelly method (1987), through bilateral olfactory bulbectomy. The control of depression was performed using the tail suspension test (Steru et al. 1985).

Testing of motor learning and memory

The spatial learning capacity and memory were evaluated using the Morris water maze test (***).

The indicators for learning were:

- number of diagonals
- number of excursions
- time in D
- latency time

The moments for the testing of the learning capacity and memory were chosen after day 7 postoperatively, and were noted with T_1 (day 1) and T_{28} (day 28).

Statistical analysis

Statistical processing was performed with the Excel application (Microsoft Office 2007) and the StatsDirect v.2.7.2 software. The graphical representation of the results used the Excel application (Microsoft Office 2007).

Results

The statistical analysis of the values of the Morris test – the learning period, considering all groups, evidenced the following:

- diagonals – highly statistically significant differences between at least two of the groups both at moment T_1 ($p = 0.0004$) and at moment T_{28} ($p < 0.0001$)
- excursions – highly statistically significant differences between at least two of the groups both at moment T_1 and at moment T_{28} ($p < 0.0001$)
- time in D – highly statistically significant differences between at least two of the groups both at moment T_1 ($p < 0.0001$) and at moment T_{28} ($p = 1.17 \times 10^{-26}$)
- latency time – highly statistically significant differences between at least two of the groups both at moment T_1 and at moment T_{28} ($p < 0.0001$).

The statistical analysis of the values of the Morris test – the control moment, considering all groups, evidenced the following:

- diagonals – highly statistically significant differences between at least two of the groups at moment T_1 ($p = 0.0001$); at moment T_{28}, no statistically significant differences were found between any of the groups ($p = 0.1721$)
- excursions – highly statistically significant differences between at least two of the groups both at moment T_1 and at moment T_{28} ($p < 0.0001$)

- time in D – highly statistically significant differences between at least two of the groups both at moment T_1 ($p = 0.0002$) and at moment T_{28} ($p = 1.15 \times 10^{-5}$).

The statistical analysis of the values of the studied indicators for unpaired samples (group C – group I) showed:

- for the Morris test – the learning period
  - diagonals – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - excursions – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - time in D – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - latency time – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
- for the Morris test – control
  - diagonals – highly statistically significant differences between the two groups at moment T_1 ($p < 0.001$)
  - excursions – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - time in D – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$).

The statistical analysis of the values of the studied indicators for unpaired samples (group C – group II) showed:

- for the Morris test – the learning period
  - diagonals – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - excursions – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - time in D – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - latency time – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
- for the Morris test – control
  - diagonals – highly statistically significant differences between the two groups at moment T_1 ($p < 0.001$)
  - excursions – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - time in D – very statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.01$).

The statistical analysis of the values of the studied indicators for unpaired samples (group I – group II) evidenced:

- for the Morris test – the learning period
  - diagonals – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - excursions – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
  - time in D – statistically significant differences between the two groups at moment T_1 ($p < 0.05$)
  - latency time – highly statistically significant differences between the two groups at moments T_1 and T_{28} ($p < 0.001$)
- for the Morris test – control
  - diagonals – the absence of statistically significant differences between the two groups at moments T_1 and T_{28} ($p > 0.05$)
  - excursions – statistically significant differences between the two groups at moment T_1 ($p < 0.05$)
  - time in D – statistically significant differences between the two groups at moment T_1 ($p < 0.05$) and highly statistically significant differences between the two groups at moment T_{28} ($p < 0.001$).

The statistical analysis of the values of the studied indicators for paired samples (moments T_1 – T_{28} in group I) evidenced:

- for the Morris test – the learning period
  - diagonals – differences without statistical significance ($p > 0.05$)
  - excursions – differences without statistical significance ($p > 0.05$)
  - time in D – differences without statistical significance ($p > 0.05$)
  - latency time – highly statistically significant differences between the two moments ($p < 0.001$)
- for the Morris test – control
  - diagonals – highly statistically significant differences between the two moments ($p < 0.001$)
  - excursions – very statistically significant differences between the two moments ($p < 0.01$)
  - time in D – statistically significant differences between the two moments ($p < 0.05$).

The statistical analysis of the values of the studied indicators for paired samples (moments T_1 – T_{28} in group II) showed:

- for the Morris test – the learning period
  - diagonals – highly statistically significant differences between the two moments ($p < 0.001$)
  - excursions – very statistically significant differences between the two moments ($p < 0.01$)
  - time in D – statistically significant differences between the two moments ($p < 0.05$)
  - latency time – highly statistically significant differences between the two moments ($p < 0.001$)
- for the Morris test – control
  - diagonals – very statistically significant differences between the two moments ($p < 0.01$)
  - excursions – statistically significant differences between the two moments ($p < 0.05$)
  - time in D – statistically significant differences between the two moments ($p < 0.05$).

Table I.

Comparative analysis for the values of the studied indicators in the two groups and statistical significance

Test			Mean	SE	Median	SD	Min.	Max.	*Statistical significance (p)* Unpaired samples	
									group C – group I	group C – group II
Morris - learning	Diagonals	T_1	1.6	0.0580	1.54	0.1834	1.42	2	**< 0.0001**	0.9965
		T_{28}							**0.0003**	**< 0.0001**
	Excursions	T_1	2.93	0.0562	2.92	0.1776	2.67	3.33	**< 0.0001**	0.0754
		T_{28}							**6.67×10^{-11}**	**< 0.0001**
	Time in D	T_1	3.58	0.1369	3.63	0.4329	2.83	4.17	**< 0.0001**	**< 0.0001**
		T_{28}							**3.66×10^{-16}**	**1.49×10^{-17}**
	Latency time	T_1	32.28	0.6745	32.67	2.1330	26.92	34,75	**< 0.0001**	**< 0.0001**
		T_{28}							**< 0.0001**	**< 0.0001**
Morris - control	Diagonals	T_1	4.9	0.3145	5	0.9944	4	7	**0.0002**	**< 0.0001**
		T_{28}							0.33	0.5196
	Excursions	T_1	10.5	0.6540	10	2.0683	8	14	**< 0.0001**	**< 0.0001**
		T_{28}							**< 0.0001**	**< 0.0001**
	Time in D	T_1	32.2	2.5465	33.5	8.0526	18	42	**< 0.0001**	**0.0015**
		T_{28}							0.0006	**0.0086**
	Latency time	T_1	60		60		60	60	–	–
		T_{28}							–	–

									group I – group II
Morris - learning	Diagonals	T_1	1.13	0.0599	1.13	0.1894	0.83	1.5	**7.87×10^{-5}**
		T_{28}	1.18	0.0593	1.17	0.1876	0.92	1.58	**5.45×10^{-10}**
	Excursions	T_1	1.8	0.0544	1.83	0.1721	1.58	2	**< 0.0001**
		T_{28}	1.88	0.0531	1.875	0.1678	1.58	2.17	**< 0.0001**
	Time in D	T_1	15.25	0.2101	15.08	0.6643	14.5	16.25	**0.0117**
		T_{28}	15.33	0.2425	15.54	0.7668	14	16.58	0.8207
	Latency time	T_1	72.35	0.5426	72.13	1.7158	69.25	74.67	**1.099×10^{-6}**
		T_{28}	67.1	0.8856	66.75	2.8004	63.75	71.92	**4.57×10^{-9}**
Morris - control	Diagonals	T_1	2.6	0.3055	2.5	0.9661	1	4	**0.8745**
		T_{28}	5.4	0.3399	5	1.0750	4	7	0.0533
	Excursions	T_1	3.4	0.2211	3.5	0.6992	2	4	**0.01**
		T_{28}	6.5	0.3727	7	1.1785	5	8	0.9091
	Time in D	T_1	16.6	0.7630	17.5	2.4129	12	19	**0.0186**
		T_{28}	19.2	0.6110	18.5	1.9322	17	22	**0.0002**
	Latency time	T_1	60		60		60	60	–
		T_{28}	60		60		60	60	–

									Unpaired samples (T_1 – T_{28})	
									group I	group II
Morris - learning	Diagonals	T_1	1.57	0.0631	1.58	0.1995	1.17	1.83	0.5461	**4.34×10^{-6}**
		T_{28}	2.13	0.0530	2.125	0.1676	1.83	2.33		
	Excursions	T_1	3.14	0.0979	3.08	0.3094	2.75	3.75	0.5703	**0.002**
		T_{28}	4.075	0.0685	4.04	0.2168	3.67	4.42		
	Time in D	T_1	16.3	0.2798	15.92	0.8847	15.5	18.08	0.8203	**0.0195**
		T_{28}	15.41	0.2182	15.375	0.6899	14.58	16.83		
	Latency time	T_1	66.14	0.6447	66.375	2.0386	63.25	69.75	**4.2×10^{-5}**	**3.61×10^{-8}**
		T_{28}	54.69	0.7222	54.92	2.2839	51.5	58.75		
Morris - control	Diagonals	T_1	2.7	0.2134	3	0.6749	2	4	**0.0005**	**0.0078**
		T_{28}	4.5	0.2687	4.5	0.8498	3	6		
	Excursions	T_1	4.9	0.4583	4.5	1.4491	3	8	**0.002**	**0.0391**
		T_{28}	6.5	0.3727	7	1.1785	5	8		
	Time in D	T_1	20.7	1.4610	20.5	4.6200	13	30	**0.0234**	**0.0469**
		T_{28}	23.6	0.7024	23.5	2.2211	19	27		
	Latency time	T_1	60		60		60	60	–	–
		T_{28}	60		60		60	60		

Discussion

Our results show that over the learning period, bilateral olfactory bulbectomy induced in group I compared to group C, at moments T_1 and T_{28}, significant decreases in the number of diagonals and excursions and significant increases in the time spent in D and the latency time. In the group with olfactory bulbectomy subjected to exercise (group II) compared to the control group C, there were significant increases in the number of diagonals and excursions at moment T_{28} and significant increases in the time spent in D and the latency time at moments T_1 and T_{28}.

For the control of learning, it was found that group I had compared to group C significant decreases in the number of diagonals at moment T_1 and significant decreases in the number of excursions and the time spent in D at moments T_1 and T_{28}. In the operated group subjected to exercise (group II), compared to the control group, there were significant decreases in the number of diagonals at moment T_1, significant decreases in the number of excursions at moments T_1 and T_{28}, and significant decreases in the time spent in D at moment T_{28}.

Group II, operated and subjected to exercise for 28 days, compared to operated and sedentary group I, had over the learning period significant increases in the number of diagonals, in the number of excursions, in the time spent in D, and significant decreases in the latency time at moments T_1 and T_{28}. In the same group, for the control of learning, there were significant increases in the number of excursions and the time spent in D at moment T_1, and significant increases in the time spent in D at moment T_{28}.

Over the learning period, in the operated group (group I), there were no significant changes for any of the indicators at moment T_{28} compared to moment T_1. The operated and exercise trained group (group II) had, at moment T_{28} compared to moment T_1, significant differences for all indicators, with increases in the number of diagonals and excursions and decreases in the time spent in D and the latency time.

For the control of learning, in group I, significant differences in the number of diagonals and excursions as well as in the time spent in D were found, which increased at moment T_{28}, and there were significant decreases in the latency time at moment T_{28} compared to moment T_1. For the control test, group II had significant changes in the number of diagonals and excursions as well as in the time spent in D at moment T_{28}, which increased compared to moment T_1.

The motor learning and memory changes studied by other authors in the same experimental model with olfactory bulbectomy induced depression tested using the maze test have shown learning difficulties (Overstreet 1993; Jones et al. 2008), the impairment of learning and memory (Hendriksen H. 2012; Baek et al. 2012) and the inhibition of learning, without the impairment of memory (Gao LC 2009).

The results obtained show a decrease in the learning capacity, without memory changes in group I, subjected to bilateral olfactory bulbectomy. Experimental depression through olfactory bulbectomy associated with physical exercise for 28 days determined in group II an increase in the learning capacity compared to the control group and group I, with a decrease in the memory capacity compared to controls and an increase in the memory capacity compared to group I.

Conclusions

1. Experimentally induced depression through olfactory bulbectomy determines a decrease in motor learning capacity, without the impairment of memory.

2. Physical exercise determines in animals with olfactory bulbectomy induced depression an increase in the learning capacity and memory compared to the sedentary group with induced depression.

3. Physical exercise is a favorable factor that may contribute to the prevention of learning and memory difficulties in depression.

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