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REDUCED COENZYME I (NADH) IMPROVES PSYCHOMOTORIC AND PHYSICAL PERFORMANCE IN ATHLETES

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Abstract:

In an open label trial the dispersion of reaction times and the ergometric performance of seventeen (17) competition level athletes (cyclists and long distance runners) have been examined before and 4 weeks after a daily tablet of 5 mg of reduced Coenzyme I (NADH). The dispersion of reaction times (DRT) became better and so did the quality and the speed of recognizing symbols in a certain pattern. In 9 of the 17 athletes the continuous attention as well as the maximum performance did improve.

Keywords:

NADH - Coenzyme I - Reaction time - Psychometric tests - Physical performance.

Introduction

Coenzyme 1, also known as Nicotinamide Adenine Dinucleotide, is present in all living cells and plays a central role in the energy production of a cell[1]. The reduced form of Coenzyme I is involved in many intracellular reduction processes[2] . Its most important function, however, is its driving force in the process of oxidative Phosphorylation by which energy is produced in the cell[3]. One molecule NADH effects the formation of three molecules adenosine triphosphate (ATP), an energy-rich compound which is needed by all cells of the body to perform the essential metabolic processes. The gain in free energy from this process is 220 kilojoule. NADH serves as central intermediate in the oxidative degradation of food and is an important carrier of reducing power in cells in which it drives the production of ATP[3]. NADH has been used in pure form as diagnostic reagent for numerous blood tests[4,5] such as lactatdehydrogenase (LDH)[6]. It has never been considered as a therapeutic agent until 1987, probably because of its high reactivity and the assumed degradation in the blood. Despite this view NADH was given to Parkinsonian patients as intravenous infusion in 1987. A beneficial effect on the symptoms was observed[7] .

In a further open label trial **415 Parkinsonian patients** were treated with NADH intravenously. 90% of the patients exhibited an improvement in their disability after NADH infusions[8]. In order to increase the practicability of application a stable oral form of NADH has been developed which rendered NADH absorbable by the intestine. **470 patients** were evaluated receiving NADH in this tablet form. The patients showed an improvement in their symptoms which was comparable to that of the patients treated with NADH intravenously. The mean value of the improvement in disability was 20%[9]. NADH exhibited a beneficial effect which was comparable to that of L-Dopa. This observation provided indirect evidence that NADH may act by stimulating dopamine production. Independent in vitro studies showed that the dopamine production in pheochromacytoma cells can be increased in a dosage-dependent manner up to 6 fold by addition of NADH to the culture medium[10]. Furthermore, NADH was able to increase tyrosine hydroxylase activity, the key-enzyme for dopamine production in these cells in a dosage dependent manner up to 70%[10]. Further evidence for the stimulatory effect of NADH on the biosynthesis of dopamine and Norepinephrine was obtained from in vivo studies. NADH stimulated the biosynthesis of doparnine in striatum of the rat brain by up to 40 % after intraperitoneal injection of NADH for 6 days[11]. Dopamine is a neurotransmitter involved in all the extra pyramidal motor tracks of the central nervous system responsible for instinctual movements and for static and dynamic muscle tone[12] . If NADH stimulates the endogenous biosynthesis of dopamine this coenzyme should have an effect on the instinctual movement and the muscle tone. Based upon these features dopamine should improve the physical and mental performance. This effect has been observed in Alzheimer and Parkinsonian patients[13].

The question was whether the beneficial effect of NADH occurs only in Alzheimer and Parkinsonian patients or also in healthy individuals. As an extreme counterpart of disabled Parkinsonian patients **we selected internationally performing athletes (cyclists and triathletes)** who regularly perform physical and mental exercises. The working hypothesis was that these young healthy well-trained individuals can profit from NADH physically and/or mentally starting with NADH, secondly 4 weeks later. One tablet containing 5 mg NADH was taken by the athletes daily before breakfast on an empty stomach for 4 weeks. The volume and the intensity of the training and exercise program of the athletes were kept constant over that period and so were the lifestyle.

Results

From the 20 patients included in the study 3 dropped out because they did not show up at the study site for their second examination after the treatment period. Hence the data of 17 athletes were evaluated. The results of the dispersion of reaction times (DRT) before and after 4 weeks of 5 mg NADH are given in table 1. In the majority of the test persons the dispersion of reaction times decreased significantly. In 5 athletes the DRT was reduced by 10 %, in 6 athletes between 10 and 20 % and in 5 persons over 20 %. The time to perform the test was considerable shorter in 16 athletes after NADH therapy; in only one athlete the DRT was not decreased. The shortening of the performance time was in 5 athletes up to 10 %, in 8 athletes 10 to 20 % and in 3 athletes over 20 %. Using the test for continuous attention we observed that the DRT was shortened in 7 athletes between 10 and 20 % and in 2 athletes over 20 %. The measurement of the vigilance did not show significant difference before and after NADH treatment.

The spiro-ergometric parameters for the physical performance before and after application of NADH are summarized in table 2. After application of NADH an increase of the maximum performance (Wmax/kg), of the maximal ventilation (VE) and of the maximum oxygen uptake (V_{02}max/kg) could be observed. With two athletes Wmax increased by more than 10 %, with seven athletes the increase was up to 10 % and with 1 athlete no change in Wmax could be observed. In six athletes a decrease of Wmax up to 10 % was observed. Similar observations were made with V_{02}max and the maximum heart frequency. **These data indicate that the physical performance could be increased by NADH in a certain number of the athletes.**

In addition to the spiro-ergometric parameter lactate levels in the blood were determined before and after 4 weeks of 5 mg NADH daily. The results are summarized in table 3. Differences in the lactate concentration after three minutes of maximum performance were found after intake of NADH. In 9 athletes an increase was observed, 4 athletes did not show any change in lactate concentration, in 4 other athletes lactate concentration was 40% lower than before NADH intake. The changes of the lactate values were statistically not significant. All the cardio respiratory parameters were in the range one would expect them for top athletes implying that their state of training was a very good one. The electrocardiogram under ergo meter condition and the blood pressure remained the same before and after 4 weeks of 5 mg NADH intake.

In addition to these tests the level of dopamine metabolites homovanillinic acid and vanillinic mandelic acid were assayed in the urine of some of the athletes. No statistically significant increase in the urine level of HVA and VMA could be found after the 4 weeks of NADH intake.

Discussion

The dispersion of reaction times (DRT) as measured by the Vienna Test system showed a shortening of the reaction time. In other words, the athletes had a faster reaction. This is a desired effect and regarded by the athlete as a positive improvement. Using the continuous attention as parameter for the reaction time a decrease by more than 10 % in 9 athletes was found. In 4 athletes an increase up to 10 % was observed. The increase in these 4 athletes could be caused by individual influences such as biorhythm, diet, lifestyle and stress situation. In those athletes where an improvement in reaction time was found NADH could have acted in various ways. One possibility could be a deficit in NADH in certain brain areas before treatment which were filled up by exogenous NADH in the 4 week treatment period. The other possibility could be an increase in dopamine production in certain brain areas leading to an increased alertness and vigilance. A stimulation of dopamine production in certain brain areas of rats after intravenous application of NADH[11] supports this assumption.

The enhancement in the physical performance in a large percentage of the athletes might be based on the stimulation of cellular ATP production by NADH. This co-enzyme can supply additional energy, if it is able to enter the cell. Preliminary experiments with radio-labeled NADH performed at an institute indicate that this coenzyme is able to cross the cell membrane and reach the cytoplasm as one site of its action[15]. The more NADH the cell has available the more energy it can produce presupposing that all the enzymes of complex 1, 11, 111 and IV are working properly[1,2,3]. If one of the enzymes of these complexes does not reach full activity, energy production in the cell goes down. This deficit in energy production is then reflected by reduced strength, power and performance. According to Corbisier and Remacle [16] alteration of mitochondria by toxic agents lead to their uncoupling causing a reduced energy production. If the cellular energy production falls below a certain threshold cells will die, a process which causes tissue degeneration in the muscle, heart and predominantly in the brain, as the brain needs 30 % of the energy produced by our organism. The enzyme NADH Cytochrome C.reductase (Complex I + 111) could be measured in 3 of the athletes. A significant increase in the activity of this enzyme was observed after 4 weeks of a daily dose of 5 mg NADH.

Regarding the possible mechanism by which NADH can increase psychornotoric activity and physical performance we can only speculate. One possibility could be that the neurotransmitter dopamine, the production of which is increased by NADH[10], increases the output of growth hormone (GH)[17]. GH has been shown to stimulate muscle growth leading to increased strength and endurance[18].

A rather long term effect of NADH and also NADPH which are readily interconvertable by a transhydrogenase may be related to the considerable impact these coenzymes have on the antioxidant capacity of erythrocytes [19,20].

From the pharmacological point of view it may be argued that NADH is very reactive and not stable enough in blood in order to induce a pharmacological effect. There are, however, proteins in the cytoplasm of red cells and probably also in the blood plasma which bind NADH[20,21]. One of these proteins is catalase by which NADH and NADPH is sequestered[21] and probably protected from degradation.

As NADH plays a crucial role for glycolysis and its regulation[22] it could enhance the generation of more energy. The increase of the oxygen capacity (V02max) in the majority of our athletes could be due to the influence of NADH on the hemoglobin affinity for oxygen[23].

In conclusion has to be pointed out that this study was an open label trial and the number of individuals tested was rather low. Hence this investigation should be regarded as a pilot study. Nevertheless, from the changes observed after taking NADH for 4 weeks it seems justified performing a double blind placebo controlled study with a larger number of athletes.

Table 1: Summary of the results of the dispersion of reaction times (DRT) - Measurements before and 4 weeks after intake of 1 tablet NADH (5 mg) per Day

n=17	**Before NADH**	**After NADH**	**Alteration per Person in percent (%)**		**Absolute Alteration Per Person (number)**		
Continuous attention	X	x	x	SD	x		SD
correct reactions	117.20	118.80	1.42	2.89			
incorrect reactions	2.71	1.59			-1.12		2.00
missed reactions	2.65	1.24			-1.41		3.22
DRT (mean value)	0.87	0.81	-6.48	12.48			
Dispersion	0.19	0.17	-11.59	23-89			
Cognitrone							
Correct reactions	185.20	190.10	2.98	6.54			
DRT (mean)	2.58	2.09	-16.05	16.94			
Working time (min)			-14.36	16.18			
Vigilance							
Correct reactions	97.94	97.88	0.01	3.28			
Incorrect reactions	1.88	1.24			-0.65		2.78
Missed reactions					0.24		3.09
DRT (mean)	0.51	0.55	7.79	19.91			
Dispersion	0.10	0.11	4.791	31-85			

Table 2: Summary of the performance parameters as measured by spiroergometry before and 4 weeks after intake of 1 tablet NADH (5 mg) per day

	before NADH					**after NADH**				
Parameters	mean	SID	min.	max.	mod.	mean	SID	min.	max	mod.
Wmax	331.00	32.90	277.00	404.00	335.00	340.00	43.90	277.0	433.00	339.00
Wmax/kg	4.70	0.40	4.10	5.60	4.60	4.90	0.60	4.10	6.00	4.60
HFmax	179.00	11.80	150.00	197.00	180.00	180-00	12.50	150.0	192.00	182.00
Vmax	150.00	20.40	106.00	177.00	148.00	163.00	23.70	137.0	218.00	155.00
V02max	4.72	0.47	4.06	5.79	4.77	4.98	0.61	3.95	5.91	4.96
V02max/kg	68.50	5.90	59.70	87.70	67.00	71.20	8.20	61.1	88.20	68.70
Rmax	1.00	0.10	0.90	1.10	1,00	1.00	0-00	1.00	1.10	1.00

Wmax = maximum performance

Table 3: Summary of lactate blood levels after maximum performance before and after 4 weeks of 1 tablet NADH (5 mg) per day

n = 17	**before NADH**		**after NADH**		**differences In percent**			
Lactate level	mean	SID	mean	SID	Dmean	Dmin	Dmax	Dmed
1 min after	8.1	3.5	9.0	3.2	10.0	-7.3	22.2	9.6
maximum								
performance								
3 min after	6.1	2.8	7.4	2.3	17.2	-22.5	70.3	-3.7
maximum								
performance								

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