INFLUENCE OF PHYSICAL EXERCISE AND SODIUM INTAKE ON ARTERIAL PRESSURE AND CARDIAC HYPERTROPHY IN RATS

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SUMMARY: Evidence shows that cardiac hypertrophy (CH) is a risk factor for many cardiovascular diseases. Several stimuli may cause CH-like manifestations and promote volume or pressure overload. Exercise-induced cardiac hypertrophy is an expected adaptation to regular exercise training. Salt intake has been shown to be the most important determinant of blood pressure in different populations. The purpose of the present work was to verify the influence of physical exercise and sodium intake on the blood pressure and myocardium. The study was performed on 36 rats divided into six groups: Group I (diet without salt overload), Group II (diet without salt overload and swimming), Group III (diet with 2.5% NaCl solution and swimming), Group IV (diet with 5% NaCl solution and swimming), Group V (diet with 2.5% NaCl solution without exercise), Group VI (diet with 5% NaCl solution without exercise). The arterial pressure was significantly lower in Group I when compared with Group IV. The ratio of cardiac mass/body mass was increased in Groups III and IV. In conclusion, there was evidence that exercise training and NaCl intake promotes arterial hypertension and cardiac hypertrophy.

DESCRIPTORS: **Arterial hypertension. Cardiac hypertrophy. Physical exercise. Saltoverload.**

Evidence shows that cardiac hypertrophy (CH) is a risk factor for many cardiovascular diseases. This condition may be associated with high blood pressure (HBP), but the relationship between these entities needs to be clarified, especially considering that CH may occur before elevations in the blood pressure.

Lowering blood pressure levels alone is not followed by regression in the CH. Some studies suggest that humoral mediators (possibly angiotensin II) may be implicated in myocardial growth, and the resulting CH is proportional to blood pressure levels.

Several stimuli may cause CH, including agents that promote volume or pressure overload. Non-athlete subjects undergoing an intensive physical conditioning program develop increased heart size, as well as improved cardiac output as an adaptation response. Myocardial malfunctioning, however, occurs after a long period of continuous volume or pressure overload. Intermittent volume overload during physical exercise is not followed by permanent cardiovascular adaptation.

Regular physical activity is related to a physiological CH as a result of left ventricular wall thickening. Athletes undertaking isotonic exercises develop eccentric ventricular hypertrophy (dilatation with increased muscular mass) and those undertaking isometric exercises develop concentric hypertrophy (thickening of the wall without dilatation).

Excess sodium chloride (NaCl) intake is considered a risk factor to HC and HBP in predisposed people. Hemodynamic mechanisms and direct action are involved. In rats, HBP can be caused by adding NaCl to their diets, and the rise in pressure levels is proportional to the salt overload. Retention of water and volemic elevation is due to blood sodium excess and the response of the renal tubules to this situation.

The purpose of the present paper is to verify the influence of physical exercise and sodium intake in the blood pressure levels and myocardium hypertrophy.

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METHODS

Thirty-six female Holtzman rats, weighing 200 to 300 g were divided into six groups according to the following design (n=6):

Group I: regular diet and water.

Group II: regular diet, water and swimming.

Group III: regular diet, 2.5% NaCl solution and swimming.

Group IV: regular diet, 5% NaCl solution and swimming.

Group V: regular diet, 2.5% NaCl solution without exercise.

Group VI: regular diet, 5% NaCl solution without exercise.

All the animals were allowed to feed and drink water or NaCl solution ad libitum according to their group.

A 110 cm x 80 cm x 80 cm box filled with water at 35oC was used to exercise the rats in groups II, III, and IV. At the beginning, they were allowed to swim for 10 minutes, twice a day, with a 4-hour interval between each section. Daily, 10 extra minutes of exercise were added until a 50-minute section was achieved.

The blood pressure was assessed using a tail sphygmomanometer, after heating the animal by placing it close to a light bulb inside a box, and achieving artery dilatation in its tail. Blood pressure and weight were measured on the first day, every two weeks, and at the end of the experiment.

On the thirty-fifth day, all animals were killed with an ether overdose. Their hearts were immediately withdrawn and weighed. The cardiac hypertrophy was assessed using the ratio of heart weight / body weight.

We used statistical parameters to choose the number of animals used in this study. All values were analyzed using the Student's t test and analysis of variance (ANOVA) test. Statistical significance was assigned to values $< p = 0.005$.

RESULTS

All animals of Group VI reduced their weight, became hypoactive, and died before the third week of study. There was no death in the other groups until the end of the experiment.

There was no significant difference in weight among the groups at the beginning of the study. The weight variation of the Group I was not significant throughout the experiment. In Group II, weight reduction occurred only after 5 weeks. The animals of the groups III, IV, and V reduced their weight after 15 days until the end of the study. The weight decrease was more pronounced in Groups IV and V (Table 1).

There was no significant difference in blood pressure among the groups at the beginning of the study. During the experiment, the mean blood pressure values of Group I were lower than those of the other groups. By the end of the experiment the difference between the Groups I and IV was significant (Table 2).

The heart weight was different between Groups IV and V. We employed the proportion cardiac weight / body weight in order to reduce the influence of the body weight. The animals of Group VI did not have their hearts weighed because they died before the end of the experiment, and it was difficult to establish when the deaths exactly occurred.

The heart weight / body weight ratios in Groups II to V were higher than in Group I (control). Differences were also observed between Group III and IV.

Table 1 – Average weight of the animals during the experiment (g.).

	1º day	14º day	28º day	35º day
I – Water	233.50 ± 28,46	243,83 ± 31,55	237,00 ± 31,41	229,00 ± 23,02
II – Water + Exercise	229.67 ± 17.56	230.00 ± 23.55	227.83 ± 21.51	201.17 ± 23.19
III – NaCl 2.5% + Exercise	270.17 ± 34.62	224.50 ± 31.35	214.33 ± 16.60	=207.00 ± 24.33
IV – NaCl 5% + Exercise	239.83 ± 11.61	188.00 ± 17.40	166.17 ± 12.71	149.17 ± 18.24
V – NaCl 2.5%	242.17 ± 17.49	174.50 ± 11.91	169.50 ± 19.38	156.17 ± 15.66
VI – NaCl 5%	241.85 ± 9.17	136.00 ± 10.23	_	_

Table 2 – Averages of the blood pressure and of the relation between heart weight/body weight.

	Blood pressure (mmHg) at 35o day	Heart weight (g.)	Heart weight / body weight (%)
I – Water	88.83 ± 6.17 *	0.766 ± 0.064	0.337 ± 0.048 **
II – Water + Exercise	94.67 ± 9.37	0.785 ± 0.133	0.389 ± 0.042
III – NaCl 2.5% + Exercíse	93.00 ± 6.16	0.923 ± 0.160	0.452 ± 0.098 **
IV – NaCl 5% + Exercíse	102.67 ± 9.91 *	0.625 ± 0.106 @	0.417 ± 0.032 **
V –NaCl 2.5%	95.33 ± 6.28	0.614 ± 0.039 @@	0.394 ± 0.018

* Significant differences occurred between these two groups (p=0.01).

@ The heart weight of group IV was less than of groups I (p=0.01), II (p=0.04) and group III (p<0.01).

@@ The heart weight of group V was less when compared with group I (p<0.01).

** The ratios of groups III (p= 0.02) and IV (p<0.01) were bigger than group I.

DISCUSSION

The decreasing weight of all groups submitted to physical exercise may be due to the enhancement of caloric consumption when compared to the sedentary groups. The greater reduction in the group that received NaCl 5% may be explained by a hypertonic dehydration. Another possibility is the decreasing of the animals' weight, as occurred in Group V, even without practicing physical exercise. The deaths of all animals of Group VI may be due to an overload of NaCl, with hypertonic dehydration.

The survival of the animals of Group IV that were given the same NaCl solution as Group VI may be due to drinking water during swimming. This possibility is questionable since it is very difficult to drink water during swimming. Another hypothesis is a better adaptation of the animals that practiced exercises to adverse conditions. The change in the BP in the group that drank the most concentrated NaCl solution, and practiced swimming, suggests a synergism between these factors, since exercise only did not induce to change in BP10.

The lower body weight in Group IV may be related to the lower heart weight in this group. In order to reduce the influence of body weight, we used the heart weight / body ratio[4,11,12]. The NaCl overload in Groups III and IV, while not changing BP, increased that ratio. This phenomenon should not be attributed to the physical exercise because Group II, which was only exposed to swimming, did not have modified heart weight / body weight ratios. Group V, which drank the 5% NaCl solution and had no exercise, did not have an increase in the heart weight / body weight ratio. We propose that it is worth hypothesizing that the interaction of NaCl solution intake and exercise is responsible for the increased heart weight / body weight ratio.

According to Perrault and Turcotte (12), when a higher body weight reduction takes place, it is more advisable to employ the heart weight / body weight ratio than the heart weight only. This criteria is adopted in the literature when the comparison is made between small organs, like the heart. In spite of the disadvantages of this method, according to those authors, it is still the most acceptable. In the present paper, we considered adequate the results achieved by that method.

In conclusion, cardiac hypertrophy and increasing blood pressure may occur in animals that intake NaCl solution and practice physical exercise. More studies must be carried out in order to clarify the influence of physical exercise on heart adaptability.

RESUMO

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SANTOS B. M. R. dos S. et al. – Influência de exercícios físicos e do cloreto de sódio na pressão arterial e hipertrofia cardíaca nos ratos. **Rev. Hosp. Clín. Fac. Med. S. Paulo 54** (4):111 - 114, 1999.

Há evidências de que a hipertrofia cardíaca (HC) seja um fator de risco para várias doenças cardiovasculares. Uma variedade de estímulos pode levar à HC, entre os quais estão condições que gerem sobrecarga de volume ou pressão, como o exercício físico e a dieta rica em cloreto de sódio (NaCl). Com o objetivo de verificar a possibilidade de o exercício físico e a ingestão de dieta rica em NaCl influenciarem na pressão arterial e trofismo miocárdico, realizou-se o presente estudo. Foram utilizados 36 ratos Holtzman, do sexo feminino, pesando entre 200 e 300 gramas, e divididos nos seguintes grupos (n=6): Grupo I (dieta com água sem NaCl), Grupo II (dieta com água sem NaCl), Grupo III (dieta com solução de NaCl a 2,5%), Grupo IV (dieta com solução de NaCl a 5%), Grupo V (dieta com solução de NaCl a 2,5%), Grupo VI (dieta com solução de NaCl a 5%). Os animais dos grupos II, III e IV praticaram natação durante 100 minutos ao dia, por cinco semanas, após as quais foram mortos e seus corações pesados. As medidas de pressão arterial (PA) e de peso durante o experimento foram comparadas. Houve diminuição do peso dos grupos submetidos a exercício físico e / ou dieta salina: Grupo I (229,0 g), Grupo II (201,17 g), Grupo III (207,0 g), Grupo IV (149,17 g) e Grupo V (156,17 g). Ao final do experimento, o grupo que foi submetido à dieta mais rica em sódio juntamente com exercício mostrou uma PA significativamente maior (102,67 mmHg) que o Grupo I (88,83 mmHg), sem fatores de risco. Houve uma maior relação peso do coração/peso corporal nos grupos III (0,452 %) e IV (0,417 %), em comparação com o Grupo I (0,337%). Concluindo, houve indícios de hipertrofia cardíaca e aumento da pressão arterial nos animais que ingeriram solução salina e realizaram exercício físico.

DESCRITORES: **Hipertrofia cardíaca. Hipertensão arterial. Exercício físico. Dieta hipernatrêmica.**

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