49 - EFFECT OF PHYSICAL EXERCISE ON LIPID METABOLISM IN RATS SUBMITTED TO HYPERCHOLESTEROLEMIC DIET

ALLAN CRISTIAN GONÇALVES, EMERSON CRUZ DE OLIVEIRA,
MARIA LÚCIA PEDROSA, MARCELO EUSTÁQUIO SILVA.
Ouro Preto / MG - Brasil

Introduction

High concentration of serum cholesterol and other related disorders of serum lipoproteins, called dislipidemias, since the decade of 1980 have been accepted as a cause of chronic degenerative diseases such as the Coronarian Arterial Disease (CAD) and other atherosclerotic diseases. Such observations were made from studies in animal models as well as in populational studies. Hypercholesterolemia is a kind of dislipidemia characterized by a high concentration of serum LDL cholesterol causing atherogenesis and increasisg the risk of CAD[13].

Ageing, genetics and mainly obesity, fat-rich dietas and sedentariness are factors that can lead to hypercholesterolemia. Physical exercice helps impairing atherogenesis and can positively influence on obesity, dislipidemia and diabetes[5,10]. Physical activity has been recognizably demonstrated to act beneficially on the factors that lead to chronic degenerative diseases; it can be used in combination with dietetic restriction for body weight reduction and prevention of obesity[4,8] potentializing their effects. Amongst the effects of physical exercise LDL and VLDL cholesterol reduction and HDL cholesterol increase are highlighted[1,9,12]. Even low intensity physical activity is capable of increasing lipolisis of adipose tissue , preserving muscle glicogen stores[6,7]. Physical activity does not contribute for the development of hepatic disorders provoked by the formation of free radicals[3].

The aim of the presente work was to assess the effect of moderate physical exercise on lipid metabolism and its effect on serum cholesterol in rats submited to hypercholesterolemic diets.

Methods

Animals and diet. Fourty eight adult female Fisher rats were utilized which were divided into four groups according to initial body weight in order to make them more homogeneous and according to the applied treatment: Exercise with hypercholesterolemic diet (EH), Exercise with control diet (EC), Sedentary with hypercholesterolemic diet (SH) and sedentary with control diet (SC). Each group had 12 animals. These received control diet AIN-93M[11] or hypercholesterolemic diet AIN-93M with fat contet modified from 4 to 25% and cholesterol added equivalent to 10% of the diet and reducing corn starch content from 72.25% to 50.25% in order to induce hypercholesterolemia. The composition of the diees is indicated in table I. Animals were given filtered water and food ad libitum and were kept in individual cages with liight/dark cicle of 12 hours. Animals, food and wastes were weighed weekly in a digital scale.

Table I. Compositon of control and hypercholesterolemic in g/ 1000 g of diet.

	Control	Hypercholesterolemic
Choline	2.5	2.5
Salt mixture[1]	35	35
Vitamin mixture[2]	10	10
Fiber	50	50
Casein	140	140
Soybean oil	40	250
Cholesterol	0	10
Corn starch	722.5	50.5

[1]Salt mixture (g/kg of mixture): NaCl 139.3 / KI 0,79 / MgSO4.7H2O 57.3 / CaCO3 381.4 / MnSO4.H2O 4,01 / FeSO4.7H2O 27.0 / ZnSO4.7H2O - 0.548 / CuSO4.5H2O 0.477 / CoCl2.6H2O 0.023 / KH2PO4 389.0. [2]Vitamin mixture (g/Kgof mixture): Retinol acetate 2.000.000IU / Cholecalciferol 200.000IU / p-aminobenzoic acid 10.00 / I-Inositol 10.00 / Niacin 4.00 / Calcium Pantotenate 4.00 / Riboflavine 0.80/ Tiamine HCL 0.50 / Piridoxine HCL 0.50 /Folic acid 0.20 / Biotin 0.04 / Vitamin B12 0.003 / Sucrose q.s.p. 1000. / Cholina 200.0 / -Tocopherol 10.000IU. Cholesterol Isofar.

Training. Animals that were exercised were adapted to the water medium (water at 31ºC ± 1º C) in the followig way: first and second days, 30 min in a shallow pool; third and fourth days two series of 15 min. with 5 min of interval in a pool 50 cm deep and in the fifth day they swung 30 min strait in the same depth as in the former day. From the second to the tenth week the exercised animals repeated the session of the fifth day of adaptation, five days/week. Sedentary animals were submitted to contact with water during 30 min in shallow pool during the hole experiment in order to go through the same stress of handling.

Biochemical evaluation. After nine weeks of training animals were sacrificed 48 hours after the last exercise session and diets were withdrawn 12 hours before sacrifice. Animals were anesthesized with ether and cut in the abdominal region up to the torax in order to expose the right braquial artery which was cut for bood collection. Blood was collected in eppendorf tubes and imediastely centrifuged for serum or plasma separation. Biochemical dosages were carried out according to manufactors instructions (Labtest Diagnóstica). *Soleus* and *extensor digitorium longus*. muscles were also localized, removed and weighed.

Nutritional evaluation. Food ingestion control was performed from third to fifth week of the experiment. Paper trays were placed under each cage in order to collect feces and food wastes of each animal, which were separated from each other and weighed, as well as the food remaining in the pots. Food ingestion was measured from the third to the fifth week. After that total food ingestion of each animal was obtained and group mean and standard deviation was calculated. Weight gain was obtained by subtracting that of the thid from that of the fifth week for each animal; group mean and standard deviation were also determined. Food efficiency was obtained by dividing weight gain by food ingestion.

Statistical analysis. Comparison between groups was made by two-way ANOVA at $p < 0.05$.

Results

Effects of training on lipid profile

I order to test the effects of moderate endurance training on the lipid metabolism animals of the four groups EH, EC, SH and SC were compared at the end of the experiment in which total cholesterol, HDL cholesterol and triglycerides were biochemically assessed (Table 2). Cholesterol levels in the rats that received the hypercholesterolemic diet were significantly

higher as compared to controls, as expected. Nevertheless cholesterol was shwn to be influenced by physical activity being significantly lower in the trained animals than in those receiving the same diet, even when this was the hyperchokesterolemic one. There was no correlation between diet and physical exercise. The results suggest that moderate physical activity was capable of positively altering the cholesterol profile in the exercised groups (Table 2). The results did not show a positive effect of exrcise on HDL cholesterol, as obseved in other works[1,9]. We believe that volume and intensity of training were not capable of beneficially augmenting the HDL cholesterol in our animals. It can be clearly observed the effect of the type of diet on HDL cholesterol, much higher in the control groups than in the hypercholesterolemic ones. Although the values of HDL cholestero were slightly higher in the exercised groups, the difference was not significant (Table 2). Triglycerides presented no difference amongst all groups (Table 2).

Oxidative stress

Parametes of the oxidative stress were also evaluated in the animals, in order to verify some possible effect of physical activity on the formation of free radicals and the concentration of total and bound sulphydril was measured(Table 3). There was no significant difference between the groups in relation to total sulphydrils. In relation to free sulphydrils there was a significant difference and an interaction between exercise and diet was observed. Paraoxonase was sensible to both treatments (diet and exercise) and a correlation between the two treatments was present (Table 3).

Table 2. Values (mean and standard deviation) of total cholesterol, HDL and tryglicerides and comparison of means in relation to diet, interaction and exercise (p<0,05).

Parameters	Cholesterol (mmol/L)	HDL (mmol/L)	Tryglicerides (mmol/L)
Exercise			
E H	4,783 ± 1,911$^{a\#}$	0,1685 ± 0,0909	0,8314 ± 0,4337
E C	1,761 ± 0,265	1,1214 ± 0,0850	0,8942 ± 0,2257
Sedentary			
S H	6,083 ± 1,599^{b}	0,1160 ± 0,0667	0,7793 ± 0,3039
S C	2,053 ± 0,662	1,1043 ± 0,2598	0,7720 ± 0,3170
Value of p			
Diet	p<0,05	p<0,05	NS
Interaction	NS	NS	NS
Exercise	p<0,05	NS	NS

Different letters indicate significant difference p<0.05. NS = non significant.

Table 3. Values (mean and standard deviation) of total and free sulphydril, paraoxonase and creatine-quinase and comparison of means in relation to diet, interaction and exercise (p<0,05).

Parameters	Total Suphydrils (g/dl)	Free Sulphydrils (g/dl)	Paraoxonase (g/dl)	Creatine-Quinase (g/dl)
Exercise				
E H	83,80 ± 39,66	95,86 ± 92,95	105,43 ± 33,33^{a}	1,444 ± 0,504
E C	209,74 ± 90,27	164,37 ± 28,33$^{a\#}$	253,13 ± 63,91	1743 ± 0,825
Sedentary				
S H	203,04 ± 128,84	105,31 ± 36,14	252,16 ± 17,82^{b}	1,288 ± 0,450
S C	259,7 ± 304,46	94,05 ± 46,04^{b}	149,94 ± 56,79	1,535 ± 0,436
Value of p				
Diet	NS	NS	p<0,05	NS
Interaction	NS	p<0,05	p<0,05	NS
Exercise	NS	NS	p<0,05	NS

Different letters indicate significant difference p<0.05. NS = non significant.

Nutritional evaluation:

Food ingestion and weight gain of the rats were monitorized for three weeks and from these resultts food efficiency was calculated. Food ingestion was significantly influenced by exercise and a correlation between diet and execise was shown(Table 4). Animals of the control group ate more than those of the hyper one.The results suggest that the energetic demand imposed by physical activity was better supplied by the hyper diet, which is more caloric than by the control one what led the rats of this group to eating more (Table 4). Such data justify the interaction between diet and execise. Even with the observed difference in relation to food ingestion weight gaiin was not different among the animals. Once known the results of food ingestion and weight gain and calculated the food efficiency there was no significant difference amongst the studied groups.

Table 4. Values (mean and standard deviation) of total food ingestion, total weight gain, food efficiency and comparison of the means in relation to diet, interaction and exercise (p<0,05).

Parameters	Food Ingestion (g)	Weight gain (g)	Food efficiency (g)
Exercise			
E H	336,50 ± 35,58^{ab}	16,75 ± 5,50	0,3838 ± 0,6410
E C	352,54 ± 23,74$^{a\#}$	12,75 ± 6,24	0,3214 ± 0,5653
Sedentary			
S H	332,93 ± 20,47^{ab}	18,75 ± 8,10	0,3371 ± 0,1170
S C	320,30 ± 18,52^{b}	14,67 ± 14,90	0,3389 ± 0,1061
Value of de p			
Diet	NS	NS	NS
Interaction	p<0,05	NS	NS
Exercise	p<0,05	NS	NS

Different letters indicate significant difference p<0.05. NS = non significant.

Evaluation of weigh of s*oleus* and *extensor digitorium longus* muscles

In order to verifting the effect of the experiment on the skeletal muscles, two isolated muscles, s*oleus* and *extensor digitorium longus* were removed from the animals and weighed. The obtained results show that exercise was responsible for a significant differencein relation to isolated *soleus* muscle but not to *extensor digitorium longus* (table 5). The muscle of the sedentary animals were heavier than those of the exercised ones receiving the same diet. In this case the difference may be attributed to the presence of more intramuscular fat in the sedentary groups.[2] (table 5)

Table 5. Comparison of means of weights (g) of muscles s*oleus* and *extensor digitorium longus* in relation to diet, interaction and exercise (p<0,05).

Parameters	*Soleus* (g)	ELD (g)
Exercise		
E H	77,5 ± 14,22	90,0 ± 10,44
E C	70,0 ± 18,09	90,0 ± 15,95
Sedentary		
S H	85,0 ± 6,74	86,67 ± 8,88
S C	88,8 ± 12,40	81,67 ±18,50
	Value of p	
Diet	NS	NS
Interação	NS	NS
Exercício	P<0,05	NS

Different letters indicate significant difference p<0.05. NS = non significant.

Conclusion

The measurement of the parameters that assess the lipid metabolism showed that physical exercise decreases the serum levels of cholesterol and, in relation to oxidative stress it does not contribute negatively for the formation of free radicals. Creatine quinase was not responsive to the volume and intensity of trainig of the present experiment. Although generally speaking the trainig protocol is considered moderate it was capable of causing a significant difference in the *soleus* muscle of the sedentary animals as compared to the execised ones. We believe that this difference can be a function of more intramuscular fat in the sedentary groups.

WE suggest for future work that the volume and/or intensity of training be increased in order to better evaluating the effect of physical execise on lipid metabolism as well as its interaction with the hypercholesterolemic diet.

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Núcleo de Pesquisa em Ciências Biológicas - NUPEB. Departamento de Alimentos, Escola de Nutrição. Universidade Federal de Ouro Preto. Campus Universitário, Morro do Cruzeiro s/n°-CEP 354000-000 Telefone 031xx8898 7759.

mesilva@enut.ufop.br

EFFECT OF PHYSICAL EXERCISE ON LIPID METABOLISM IN RATS SUBMITTED TO HYPERCHOLESTEROLEMIC DIET

Abstract:

The so-called dislipedemias have been appointed as a factor causing chronic degenerative diseases as Coronarian Arterial Disease (CAD) and other aterosclerotic diseases. Hypercholesterolemia is a kind of dislipidemia characterized by a high concentration of LDL serum cholesterol, causing aterogenesis and increasing the risk of CAD. Physical activity has been demonstrated to act beneficially on the factors leading to chronic degenerative diseases and having its effect potentialized when combined with a balanced diet. In the present work 48 female Fisher adult rats were distributed into four groups: Execice (swimming 30 min/day, 5 days/week) with Hypercholesterolemic Diet, Exercice with Control Diet, Sedentary with Hypercholesterolemic Diet and Sedentary with Control Diet. After 9 weeks the animals were sacrificed. The obtained results show that exercice was efficient in reducing total cholesterol, influenced in the wheight of soleo muscle and

there was indication of effect on the oxidative stress as shown by increase in the concentration of free sulphydril groups and reduction of paraoxonase activity. The results indicate that low intensity training is capable of altering positively the cholesterol profile and suggest that new studies be made with different volumes and intensities of training.

Key words: Physical exercice; Dislipidemia; metabolism.

EFFET DE EXERCICE PHYSIQUE SUR LE MÉTABOLISME DE LIPIDE CHEZ LES RATS SOUMIS AU RÉGIME HYPERCHOLESTÉROLÉMIE

Abstrait :

Les dyslipipoprotéinémies ont éte indiqué comme um facteur qu'il entraîne des maladies chronique-dégénérée dans le domaine de la maladie artérielle coronairienne (DAC) et des autres maladies liée à l'artériosclérose. L' hypercholestérolémie est une dyslipipoprotéinémies et elle est caractérisée par une haute concentration du LDL cholestérol soyeux, celui qui entraîne l' athérogenèse et augment lerisque de la DAC. L'activité physique a montré qu'elle agit d'une façon bénéfique sue les facteurs qu'ils entrîanent des maladies chronique-dégénérée, et elle est um potentiel pour la santé quand elle est liée a une diète équilibrée. Dans cette expérimentation, on a constitué quatre groupes, avec 48 rats de la famille Fisher qui ont été soumis a des conditions suivantes: activité physique (nager 30 min/jour, 5 jour/semaine) avec une diète hypercholestérolémie (EH) ; activité physique avec une diète controlée; sédantaire avec une diète hypercholestérolémie (EH). L' expérimentation a durée neuf semaine, et après cette période ont a sacrifié les animaux. Les résultats ont montré que l'activité physique a éte efficace en fonction de la réduction du cholestérol total, et qu'elle a eu de l'influence das le poids du muscle *soleus* et il y a eu des indications sur la réduction de la fatigue oxydant, ce qui a démontré pour l'augmentation des sulphydrite libres, et la réduction de l'activité de paraoxonases. Les résultats montrent que une activité physique légère deviens capable d'altérer le profil du cholestérol positivement, et ils montrent aussi que'il est nécessaire une continuation de cette expérimentation en changeant les volumes et les intensités de l' activité physique.

Mots clés: Exercice physique; dyslipipoprotéinémies; métabolisme.

EFECTO DEL EJERCICIO FÍSICO SOBRE EL METABOLISMO DE LÍPIDOS EN RATAS SOMETIDAS A UNA DIETA HIPERCOLESTEROLÉMICA

Resumem:

Lãs llamadas dislipidemias hán sido apontadas como factor causador de enfermedades cronico-degenerativas como la Enfermedad Arterial Coronariana (EAC) y otras enfermedades ateroscleróticas. La hipercolesterolemia és um tipo de dislipidemia caracterizada por una elevada concentración del LDL colesterol del suero causadora de la aterogênesis y que eleva el riesgo de la EAC. La actividad física reconocidamente se tiene demostrado actuar beneficamente sobre los factores que llevam a las enfermedades cronico-degenerativas, y su efecto és potencializado cuando combinada con una dieta equilibrada..En el presente trabajo 48 ratas Fisher hembras adultas fueron distribuidas en cuatro grupos: Ejercicio (natación 30 min/dia, 5 dias/semana)con Dieta Hipercolesterolémica (EH), Ejercicio con Dieta Control (EC), Sedentario con Dieta Hipercolesterolemica (SH) y Sedentario con Dieta Control (SC). Después de 9 semanas los animales fueron sacrificados. Los resultados obtenidos muestran que el ejercicio fué eficaz en reduzir el colesterol total y influenció en el peso del músculo soleo pero hubo indicativo de “stress” oxidativo, como demostrado por el aumento de la concentración de sulfidrilas libres y redución de la actividade de paraoxonasis. Los resultados indicán que el entrenamiento de baja intensidad puede alterar el perfil del colesterol positivamente y sugeren que sean hechos nuevos estudios con diferentes volumens y intensidades de ejecicio.

Palabras-llave: Ejecicio físico; Dislipidemia; metabolismo.

EFEITO DO EXERCÍCIO FÍSICO SOBRE O METABOLISMO DE LIPÍDIOS EM RATOS SUBMETIDOS À DIETA HIPERCOLESTEROLÊMICA.

Resumo:

As chamadas dislipidemias têm sido apontadas como fator causador de doenças crônico-degenerativas como Doença Arterial Coronariana (DAC) e outras doenças ateroscleróticas. A hipercolesterolemia é um tipo de dislipidemia caracterizada por uma elevada concentração do LDL colesterol sérico causadora de aterogênese e que aumenta o risco de DAC. A atividade física, reconhecidamente tem demonstrado atuar beneficamente sobre os fatores que levam as doenças crônico-degenerativas, tendo seu efeito potencializado quando combinada com dieta equilibrada. No presente trabalho 48 ratas Fisher adultas foram distribuídas em quatro grupos: Exercício (natação 30 min/dia, 5 dias/semana) com Dieta Hipercolesterolêmica (EH), Exercício com Dieta Controle (EC) Sedentário com Dieta Hipercolesterolêmica (SH) e Sedentário com Dieta Controle (SC). Após 9 semanas os animais foram sacrificados. Os resultados mostram que o exercício foi eficaz em reduzir o colesterol total, influenciou no peso do músculo sóleo e houve indicativo de efeito no estresse oxidativo, como demonstrado pelo aumento da concentração de sulfidrilas livres e redução da atividade de paraoxonase. Os resultados indicam que o treinamento de baixa intensidade é capaz de alterar o perfil de colesterol positivamente, e sugerem que sejam feitos novos trabalhos com diferentes volumes e intensidades e treinamento.

Palavras-chave: Exercício físico, Dislipidemia, metabolismo.