13 - LIPID PROFILE OF MALNOURISHED AND NUTRITIONALLY RECOVERED TRAINED AND SEDENTARY RATS

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INTRODUCTION

Malnutrition in the child impairs directly the dynamics of growth and development (TORUN & CHEW, 1994; ROLLAND-CACHERA, 1998) and the same occurs in experimental animals (REICHLING & GERMAN, 2000). It has been shown that exercise can be beneficial in the process of nutritional recovery. The effect of physical training on muscle growth of malnourished rats was studied by TORUN & VITERI (1994) and GALDINO *et al.* (2000) and both observed more body growth of trained rats as compared to sedentary ones. The same effect was observed in children recovering from protein malnutrition (TORUN & VITERI, 1994).

Positive effects of exercise on growth and development of malnourished animals have been observed (ORTON *et al.*, 1985; SAKAMOTO & GRUNEWALD, 1987). Nevertheless data obtained by BABIRAK *et al.*, (1974) and CREWS *et al.*, (1969) did not show any effect and this may be due to differences in the experimental models used as well as in the exercise protocols.

Physical exercise can be divided into two distinct modalities according to the prevailing type of metabolism: aerobic and anaerobic exercise. Aerobic exercise such as jogging, running and swimming are used for improving cardiovascular conditioning and its maintenance. Amongst anaerobic ones such as resisted exercise are utilized for augmenting muscle force and resistance. Both can be quantified in relation to their volume (total time of a training session, number of repetitions of a determined exercise) and intensity of work (which refers to the magnitude of overcharge). Some authors utilize in their experiments one single session of exercise when they wish to assess the acute effect of exercise while others prefer repeated session of systematized exercise where the objective is to observe the chronic effect, thus characterizing the influence of physical training related to various factors of the organism.

Some authors indicate a relationship between infant malnutrition and development of the metabolic syndrome (obesity, insulin resistance, hypertension and dislipidemias) in adult age (LEVIN, 2006). On the other hand it is well recognized that that physical exercise is beneficial in the reduction of plasma lipids levels (BURNEIKO *et al.*, 2006). Moreover we did not find information on the lipid profile of trained and nutritionally recovered rats.

OBJECTIVE

To evaluate the effect of physical training of low volume and intensity on weight and lipid profile of female rats submitted to post-weaning protein calorie malnutrition and nutritional recovery.

MATERIAL AND METHODS

Animals

Fifty two female Fisher rats were divided into six groups: control sedentary (CS), control trained (CT), recovered sedentary (RS), recovered trained (RT), malnourished sedentary (MS) and malnourished trained (MT). Animals received filtered water and food *ad libitum* and were kept in a room with dark/light cycle of twelve hours and temperature 25 ± 1 ºC.

Diets and malnutrition protocol

During the experiment diet AIN-93M (REEVES *et al.*, 1993) was used, with modifications in protein concentration (Table I). Right after weaning, at 28 days of age animals of the malnourished group received non-protein diet for 30 days while control one was given AIN-93M diet. After this the malnourished group was divided into two. Half received a low protein (6% casein) diet and the others received the control diet and this was the recovered group. Concomitantly all groups were equally divided into trained and sedentary.

Table I. Composition of diet in g/1000g of diet.

osition/Diets	Non-protein	Low protein	Control (AIN-93M)
n	0.0	60.0	140.0
	40.0	40.0	40.0
n mixture[2]	10.0	10.0	10.0
mixture[1]	35.0	35.0	35.0
	50.0	50.0	50.0
ne	2.5	2.5	2.5
Starch	862.5	802.5	722.5

[1]Vitamin mixture (g/Kg de mistura): 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. / Choline - 200.0 / -Tocopherol - 10.000IU [2]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.

Training

Exercised animals were initially adapted to water at 31ºC ± 1 ºC in the as follows: First and second days, 30 min. in a shallow pool. Third and fourth days, two series of 15 min by 5 min. interval in a pool 50 cm deep and in the fifth day they swum 30 min continuously in this same depth. From the second to the ninth week exercised animals repeated the session of the fifth day of adaptation, 5 days/week. Sedentary animals were submitted to contact with water during 30 min. in a shallow pool during the hole experiment in order to undergo the same handling stress.

Nutritional and biochemical evaluation

The control of food ingestion was done during the last three weeks of experiment. Thus it was possible to calculate Food Efficiency (weight gain/food ingestion). After nine weeks animals were sacrificed 48 hours after the last session of exercise and 8 hours of fasting. Blood was collected and immediately centrifuged for serum separation. Biochemical determinations were performed using laboratory Labtest Diagnóstica kits according to manufacturer's instructions. After blood collecting abdomens were opened for liver separation and weighing.

Statistical analysis

Comparison among groups was done by two-way ANOVA ($p<0.05$) followed by *post hoc* Bonferroni.

RESULTS

Nutritional evaluation

Statistical analysis showed that for food ingestion, weight gain and food efficiency an effect was seen only when nutritional status was considered. Food ingestion values were significantly higher in groups CS and CT, with intermediate values for groups RS and RT while MS and MT had the lowest values. Both weight gain and food efficiency were higher in the recovered groups, followed by controls and lower values for malnourished ones (Table II).

Table II - Food ingestion, weight gain and food efficiency of malnourished, nutritionally recovered and control animals, sedentary or trained for nine weeks[1].

roups\Parameters	Food Ingestion (g)	Weight gain(g)	Food efficiency
CS	320.3 ± 18.52	28.75 ± 13.23	0.2895 ± 0.13
CT	352.5 ± 23.74	28.25 ± 6.98	0.2653 ± 0.06
RS	285.2 ± 26.39	45.45 ± 9.97	0.5139 ± 0.14
RT	255.1 ± 25.25	46.34 ± 6.06	0.5576 ± 0.07
MS	205.1 ± 80.90	4.14 ± 7.99	0.0688 ± 0.11
MT	187.1 ± 71.27	5.00 ± 8.00	0.1405 ± 0.23
	Value of p		
Nutritional status	< 0.05	< 0.05	< 0.05
Training	NS	NS	NS
Interaction	NS	NS	NS

[1]Results are expressed as mean ± standard deviation (grams).NS = non significant.

Body and liver weight

A significant difference in body and liver weight was observed as an effect of the nutritional status . Both were higher in control animals, intermediate values were found for recovered and lower values for malnourished ones. Training itself did not interfere in these parameters (Table III). Nevertheless an interaction between nutritional status and training was seen in body weight; groups CS, CT and RS showed higher values, and group RT had lower values than groups CS and CT. MS and MT animals had the lowest values as compared to the others; liver weight was significantly higher in CS, CT and RS animals, in relation to group RT. The significant difference was also found in relation to group MT and between this and MS which showed the lowest values (Table III).

Table III - Body and liver weights of malnourished, nutritionally recovered and control animals, sedentary or trained for nine weeks[1].

Groups\Parameters	Body wheight	Liver weight
CS	206.83 ± 13.68[a]	5.87 ± 0.51[a]
CT	201.17 ± 13.17[a]	5.79 ± 0.55[a]
RS	186.17 ± 15.38[a, b]	5.84 ± 0.41[a]
RT	170.28 ± 7.18[b]	4.84 ± 0.46[b]
MS	55.14 ± 16.31[c]	2.00 ± 0.61[d]
MT	74.14 ± 19.63[c]	3.04 ± 0.66[c]
	Value of p	
Nutritional status	< 0.05	< 0.05
Training	NS	NS
Interaction	< 0.05	< 0.05

[1]Results are expressed as mean ± standard deviation (grams). NS = non significant. Different letters in the same column indicate significant difference.

Lipid profile

Nutritional status had effect upon all analysed parameters. Total cholesterol and its fractions were significantly higher in groups MS and MT, intermediate in groups CS and CT and lower in RS and RT animals (Table IV). HDL cholesterol was higher in MS and MT animals, followed by RS and RT while CS and CT had the lowest values. Triglycerides in control animals were the highest while malnourished and recovered animals showed no significant difference (Table IV). Training interfered on HDL cholesterol, with sedentary animals having the highest values; on the other parameters no significant difference was observed. No interaction between nutritional status and training was detected for any parameter of lipid profile (Table IV).

Table IV - Serum concentrations of total cholesterol, HDL cholesterol, other fractions (VLDL and LDL) and triglycerides of malnourished, nutritionally recovered and control animals, sedentary or trained for nine weeks[1].

ps\Parameters	Total Cholesterol	HDL	Other fractions	Triglycerides
CS	2.05 ± 0.66	1.10 ± 0.26	0.73 ± 0.17	0.77 ± 0.32
CT	1.69 ± 0.19	1.07 ± 0.21	0.54 ± 0.12	0.89 ± 0.22
RS	1.92 ± 0.25	1.64 ± 0.24	0.28 ± 0.10	0.52 ± 0.14
RT	1.58 ± 0.22	1.22 ± 0.31	0.36 ± 0.18	0.52 ± 0.11
MS	2.10 ± 0.50	1.55 ± 0.14	0.86 ± 0.38	0.52 ± 0.11
MT	2.20 ± 0.55	1.37 ± 0.20	0.69 ± 0.17	0.51 ± 0.14
		Value of p		
utritional status	< 0.05	< 0.05	< 0.05	< 0.05
Training	NS	< 0.05	NS	NS
Interaction	NS	NS	NS	NS

[1]Results are expressed as mean ± standard deviation (mmol/L). NS = non significant.

DISCUSSION

Nutritional recovery was effective in rising body weight of the animals, minimizing the effects of malnutrition. The control diet used in group RS was efficient in restoring body mass, making it equal to that of groups CS and CT. Nevertheless the energy demand imposed to group RT prevented these animals from reaching the values obtained by control ones.

There was interaction between physical exercise and nutritional status for liver weight; values of group MT higher than in group MS, what suggests that exercise may have favored lipid accumulation in this organ. TAYLOR *et al.* (1972), observed in rats treated with diets similar to those ingested by children in Nigeria histological characteristics of fatty liver. Analysis revealed increase in total and neutral lipids such as cholesterol esters, triglycerides, mono and diglycerides and fractions of fatty acids. LEWIS *et al.*(1964) in an attempt of explaining the fatty liver proposed that a fall in glycemia would mobilize fat stores, with more fatty acids release from adipose tissue for blood stream and subsequent transfer to the liver. We believe that in physical exercise the activation of adipose tissue lipase would enhance the mobilization of fatty acids what justifies the higher weight of the liver in group MT as compared to MS. Taking into account that accumulation of hepatic fat may trigger various pathological processes our data suggest that the practice of physical exercises in protein calorie malnourished individuals can be non beneficial.

The diet for inducing malnutrition increased cholesterol and consequently its fractions. In the circulation this substance is associated with plasma lipoproteins: LDL, HDL and VLDL. Metabolization of these lipoproteins depends on various apolipoproteins, as well as the removal of these lipoproteins from blood stream depends on the presence of protein receptors in the membrane of the hepatocytes. It is suggested that deficiency in protein synthesis caused by malnutrition may have impaired the removal of circulating cholesterol thus contributing for the increase in total cholesterol in the malnourished group.

A decrease in triglycerides levels in the plasma of the malnourished and recovered animals may result in their increase in the liver, inducing fatty liver. And we believe that the increase in HDL of malnourished animals reflected the tendency observed for total cholesterol and this did not happen in the recovered group due to the reduction of other fractions (LDL and VLDL). Other cholesterol fractions did not decrease in the control and malnourished groups.

CONCLUSION

Nutritional recovery resulted in higher weight gain and food efficiency.

There was interaction between exercise and nutritional status for liver weight in malnourished animals with higher values for trained than for sedentary ones.

Cholesterol concentration, both total and fractions were higher in malnourished animals. Training reduced HDL cholesterol apparently due to a tendency to total cholesterol decrease observed in control and recovered groups but not in malnourished rats.

Considering lipid profile our data suggest that training may be beneficial for animals that received a normoproteic diet even if they were formerly submitted to malnutrition.

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LIPID PROFILE OF MALNOURISHED AND NUTRITIONALLY RECOVERED TRAINED AND SEDENTARY RATS

ABSTRAC

The goal of this work was to verify whether malnutrition causes modifications in lipid profile and if nutritional recovery associated or not with exercise (swimming, 30 minutes/day, five days/week during 8 weeks) can interfere in this process. Fifty two Fisher female rats were divided into six groups: Control sedentary (CS), control trained (CT), recovered sedentary (RS), malnourished sedentary (MS) and malnourished trained (MT). It was observed that recovered animals had higher weight gain and food efficiency. There was interaction between exercise and nutritional status for liver weight, with values of group MT being higher than those of MS. Total cholesterol and fractions concentrations were higher in the malnourished animals. Our data show that training reduced cholesterol level only in the animals that received the normoproteic diet, even if they were formerly submitted to malnutrition.

KEY WORDS: Malnutrition, exercise, lipid profile

PROFIL LIPIDIQUE DE SOURIS DENUTRIES ET RECUPEREES NUTRITIONNELLEMENT ENTRAINEES ET SEDENTAIRES

RESUME

L'objectif de cette recherche a été celui-ci de vérifier si la dénutrition cause de modifications dans le profil lipidique, et, si la récupération nutritionnelle associée ou non pas associée à l'exercice (la natation 30 minute par jour, 5 jour par semaine pendant huit semaines) peut intervenir dans ce procès. Ils ont été utilisés 52 souris Fischer distribuées en six groupes : contrôle sédentaire (cs) ; contrôle entraîné (ct) ; récupéré sédentaire (rs) ; récupéré entraîné (rt) ; dénutri sédentaire (ds) et dénutri entraîner (dt). Nous observons que les animaux récupérés ont présents les plus grandes « prises de poids et efficacité alimentaire ». Il a été constaté l'interaction entre « exercice et état nutritionnel » pour le poids du foie, étant que les valeurs du groupe dt ont été plus grandes que les valeurs du groupe ds. Les concentrations de cholestérol total et les fractions de cholestérol ont été plus grands dans les animaux dénutris. Nos résultats montrent que l'entraînement a réduit les niveaux de cholestérol seulement dans les animaux qui ont reçu la diète normale-protéique, même si soumis antérieurement à dénutrition.

MOTS-CLES: Dénutrition, exercice, profil lipidique.

PERFIL LIPÍDICO DE RATAS DESNUTRIDAS Y RECUPERADAS NUTRICIONALMENTE ENTRENADAS Y(O) SEDENTÁRIAS

RESUMEN

El objectivo de este trabajo fué verificar si la desnutrición causa modificaciones en el perfil lipídico y si na recuperación nutricional, asociada o no al ejercicio físico (natación 30 minutos por dia, 5 dias por semana durante 8 semanas) puede interferir em el proceso. Fueron utilizadas 52 ratas Fisher hembras, distribuídas em seis grupos: Control Entrenado (CE), Control Sedentário (CS), Recuperado Sedentário (RS), Recuperado Entrenado (RE), Desnutrido Sedentario (DS) y Desnutrido Entrenado (DE). Observamos que los animales recuperados apresentaran mayores gaño de peso y eficiencia alimentar. Hubo interacción entre ejercicio físico y estado nutricional para peso del hígado, sendo los valores del grupo DE mayores que los del DS. Las concentraciones de colesterol total y fraciones fueron mayores en los animales desnutridos. Nuestros resultados muestran que el entrenamiento redució los niveles de colesterol somente en los animales que receberan dieta normoproteica, aunque sendo sometidos anteriormente a la desnutrición.

PALABRAS-LLAVE: Desnutrición, ejercicio, perfil lipídico.

PERFIL LIPÍDICO DE RATOS DESNUTRIDOS E RECUPERADOS NUTRICIONALMENTE TREINADOS E SEDENTÁRIOS

RESUMO

O objetivo desse trabalho foi verificar se a desnutrição causa modificações no perfil lipídico e se a recuperação nutricional associada, ou não, ao exercício (natação 30 minutos por dia, 5 dias por semana durante 8 semanas) pode interferir nesse processo. Foram utilizadas 52 ratas Fisher, distribuídas em seis grupos: Controle Sedentário (CS), Controle Treinado (CT), Recuperado Sedentário (RS); Recuperado Treinado (RT); Desnutrido Sedentário (DS) e Desnutrido Treinado (DT). Observamos que os animais recuperados apresentaram maiores ganhos de peso e eficiência alimentar. Houve interação entre exercício e estado nutricional para peso do fígado, sendo os valores do grupo DT maiores que os valores do grupo DS. As concentrações de colesterol total e das frações de colesterol foram maiores nos animais desnutridos. Nossos dados mostraram que o treinamento reduziu os níveis de colesterol somente nos animais que receberam dieta normoprotéica, mesmo tendo sido submetidos anteriormente à desnutrição.

PALAVRAS-CHAVE: Desnutrição, exercício, perfil lipídico.