159 - PERCENTAGE OF CARBOHYDRATE AND LIPID CONTRIBUTION DURING PROGRESSIVE EXERCISE ON TYPE II DIABETES MELLITUS

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INTRODUCTION

The prevalence of type 2 Diabetes Mellitus (T2D) continues to rise, and sedentary lifestyle and obesity are recognized as key risk factors.T2D patients are characterized by impaired substrate uptake (BLAAK et al., 2000; KELLEY & SIMONEAU, 1994). Using a specific protocol of exercise calorimetry (PEREZ-MARTIN et al., 2001; BRANDOU et al., 2006), was recently reported (GHANASSIA et al., 2006) that the defect in lipid oxidation during exercise in such patients can be described as the balance of substrates used for oxidation during exercise being shifted towards a lower maximum peak of lipid oxidation and lower exercise-intensity levels.

The mobilization and use of endogenous substrates during exercise are important for energetic metabolism and athletic performance. Moreover, exercise intensity and endurance training are known to be the 2 main factors in determining the balance of substrate use during exercise (BROOKS, 1997). Endurance training enhances the ability to consume lipids during mild-to-moderate exercise intensity, but the transition to hard exercise appears to result in a crossover to predominantly carbohydrate (CHO) use (BROOKS & MERCIER, 1994). In agreement, several authors have shown that regular exercise decreases CHO use and increases lipid use (COGGAN et al., 1992; JEUKENDRUP et al., 1997) during moderate-intensity exercise, whereas others have shown a higher ability to use glucose (MALETTA et al., 2001; FRIEDLANDER et al., 1997; MANETTA et al., 2002) and CHO preferentially during hard-intensity exercise (MANETTA et al., 2002; ROMIJN et al., 1993). Although few studies have been performed specifically in diabetic type II populations, marked alterations in the pattern of substrate use seem to occur in a session of progressive exercise.

In T2D, the exercise intensity that should be used for training remains controversial. In 27 studies reviewed in a recent meta-analysis by Snowling and Hopkins (2006), intensities ranging from 40 to 85% of VO_2 have been applied. On the whole, all protocols appear to be beneficial, but the meta-analysis was unable to demonstrate an influence of exercise intensity on the effectiveness of training. A likely explanation of this apparently paradoxical lack of intensity effect may be that the effect of exercise intensity on lipid oxidation is not linear, but a bell-shaped curve, reaching a maximum peak of lipid oxidation, followed by a decrease at higher intensities.

Thus, the aim of our study was to investigate the effects of progressive exercise protocol in T2D patient, carried out at the percentage of the lipid and carbohydrate contribution to muscle energy in different intensities by indirect calorimetry.

METHODS

The transversal clinical case was performed with a T2D male patient with physical, clinical and anthropometric characteristics followed: age (years): 59; height (cm): 173; weight (kg): 101.2; body mass index (BMI, kgm^{-2}): 33.81; rest systolic blood pressure (mmHg): 130; rest diastolic blood pressure (mmHg): 90; rest heart rate (bpm): 75; fasting blood glucose ($mmol\ L^{-1}$): 8.8. This patient is poorly active and not engaged in any other training programs. The patient was treated with oral hypoglycemiant antidiabetic drug only (Sulfonylurea, 125 mg of clorpropamida), and none received insulin or had clinical signs of long-term diabetic complications. The medication was withheld 24 hours before the experiment. Informed consent was obtained from patient after explanation of the nature of the study and the risks related to their participation. The study was approved by the local ethics committee.

EXERCISE TESTING

The exercise test was performed at 9 a.m. after an overnight fast on an electromagnetically-braked cycle ergometer (Cateye Ergociser-EC-1600) that was connected to a breath device (Teen 100) to measure gas exchanges (VO_2 and VCO_2).

The maximal test consisted in initial load of 25 watts and incremental load of 25 watts each two minutes in accordance with the Astrand protocol (ACSM, 2006).

CARBOHYDRATE AND LIPID OXIDATION ANALYSIS DURING EXERCISE

Indirect calorimetric measurements were performed to determine whole-body lipid and carbohydrate consumption. VO2 and VCO2 were determined in each stage of two minutes during ten minutes of test according to Perez-Martin et al. (2001). Lipid and carbohydrate oxidation was calculated on the basis of the gas-exchange measurements, according to the non-protein respiratory quotient (*R*) technique (PERONNET & MASSICOTTE, 1991), as protein breakdown contributes little to energy metabolism during exercise (LEMON, 2000). The values of lipid and carbohydrate oxidation were obtained according the following equation (PERONNET & MASSICOTTE, 1991):

Lipid oxidation (mg/min) = 1.6946 VO2 - 1.7012VCO2 (with VO2 and VCO2 expressed in mL/min).

Carbohydrate (mg/min) = 4.585VCO2 3.2255VO2 (with *V*O2 and *V*CO2 expressed in mL/min).

We calculated the balance between fat and CHO oxidation during ten minutes of protocol.

RESULTS

The heart rate increased proportionally to the load increase during physical test, presenting a normal physiological alteration (Figure 1). The heart rate reached maximum value in the tenth minute of test (128 bpm). However, this value of heart rate represented only 60% of the reserve heart rate to subject. This stage of test reached the peak of oxygen consumption (VO_{2peak}=16 mL/kg/min). These results show a normal physiological behavior during a progressive test, however, they show a

decrease in the cardio-respiratory capacity, which commonly is observed in T2D (ACSM, 2006). The systolic blood pressure has proportional increase during load increment, and the diastolic blood pressure keeping stable during different phases of test, signaling discrete elevation, which corresponds to a normal and physiological behavior (ACSM, 2006).

The progressive protocol of exercise promoted increase in CHO consumption and decrease in fatty consumption in intensity-dependent form, already shown in previous studies (BROOKS & MERCIER, 1994; ROMIJN et al., 1993). The percentage of CHO (43%) and fatty consumption (57%) were similar in the first stage of test (25 W). After the second stage of the test (50 W), was observed a representative reduction of the consumption of fatty (27%) compared with carbohydrates (73%), signaling that the exercise directs-itself for a predominant CHO consumption.

The major fatty consumption occurred in the minor load of test (25W), where the exercise heart rate was in 120 bpm, represented ~50% VO_{2peak} and 45% of reserve heart rate. This result is particularly interesting, once the intensity of exercise prescribed for diabetic patients is generally bigger that 50% of reserve heart rate and 60% of VO_2 (SNOWLING & HOPKINS, 2006), suggesting a predominant CHO consumption in intensities superior the 45% of reserve heart rate. In addition, this major CHO consumption can prompt hypoglycemia during the physical exercise in diabetic patients.

The characterization of the proportion between the consumption of CHO and of fatty during the exercise can signal to better choice of intensities for programs that aim at the loss of fat batter, in special, for T2D, where generally obesity accompanies a resistance to insulin and development of chronic-degenerative illnesses.

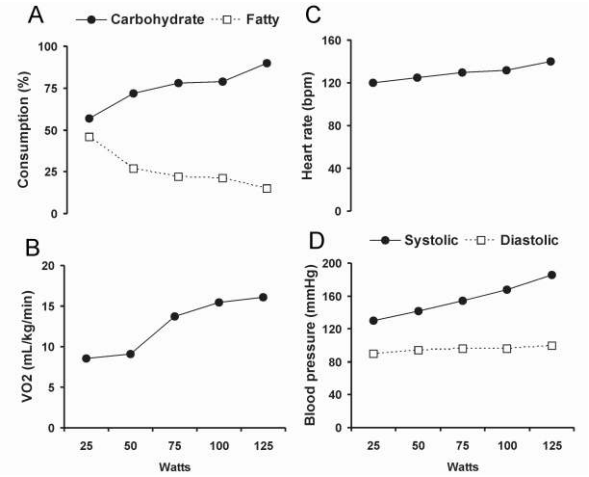

Figure 1. Measurements of metabolic (indirect calorimetry) and physiological parameters during progressive protocol in cycle ergometer on type 2 Diabetic patient: Percentage of CHO and Fatty consumption (A); Oxygen consumption (B); Heart rate (C) and blood pressure (D).

DISCUSSION

The present study showed the effect of different intensities of exercise in the percentage of CHO and Fatty consumption on T2D patient. The results suggest the exercise prescription in intensives between 45-50% of VO_{2peak} to optimized Fatty consumption on T2D patient. Recently was reported (GHANASSIA et al., 2006) defect in lipid oxidation during exercise in T2D patients. These alterations can be described as the balance of substrates used for oxidation during exercise being shifted towards a lower maximum peak of lipid oxidation (LIPOXmax) and lower exercise-intensity levels. In addition, in T2D patients, skeletal muscle mitochondrial function appears to be disturbed, leading to, in particular, reduced activity of the electron transport chain (KELLEY et al., 2002; TOLEDO et al., 2006). However, this mitochondrial dysfunction remains controversial (BOUSHEL et al., 2007). Nevertheless, it is well established that mitochondria are adaptable organelles directly involved in substrate oxidation, and skeletal muscle can manifest considerable plasticity of mitochondrial activity in response to training in insulin-resistant states, in obese individuals (BRUCE et al., 2006) and in T2D patients, as has been recently shown (TOLEDO et al., 2007). Interestingly, the defect in lipid oxidation found in both obese and insulin-resistant patients is also highly sensitive to training and, thus, is rapidly corrected by endurance training targeted at the LIPOXmax (DUMORTIER et al., 2003; BRANDOU et al., 2003). Therefore, it appeared to be logical to extend this approach to people with T2D. Thus, indirect calorimetry is a good strategy to more effective prescription of intensives inside program of exercise-induced fatty oxidation.

CONCLUSION

Finally, in our study, we found an improvement in lipid oxidation in very low intensives during maximal test protocol with indirect calorimetry use. This suggests that the main effect of very low-intensity exercise protocol probably improves the use of intramuscular lipids that are reportedly increased in T2D (BLAAK et al., 2000). In conclusion, the present study shows that a very low intense exercise-protocol (45-50% of VO_{2pico}) can be very important to improve the ability to oxidize lipids during exercise in T2D patients.

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PERCENTAGE OF CARBOHYDRATE AND LIPID CONTRIBUTION DURING PROGRESSIVE EXERCISE ON TYPE II DIABETES MELLITUS

ABSTRACT

The mobilization and use of endogenous substrates during exercise are important for energetic metabolism and athletic performance. In T2D, the better exercise intensity that should be used for training and fatty oxidation remains controversial. The aim of our study was to investigate the effects of progressive exercise protocol in T2D patient, carried out at the percentage of the lipid and carbohydrate contribution to muscle energy in different intensities by indirect calorimetry. The transversal clinical case was performed with T2D male patient with age (years): 59; height (cm): 173; weight (kg): 101.2; body mass index (BMI, kgm^{-2}): 33.81; fasting blood glucose (mmol L^{-1}): 8.8. This patient is poorly active and not engaged in any other training programs. The results suggest the exercise prescription in intensives between 45-50% of VO_{2peak} (8,5 mL/kg/min) to optimized Fatty consumption on T2D patient.

KEYWORDS: Type 2 diabetes; indirect calorimetry; carbohydrate, fatty, exercise.

POURCENTAGE DE CONTRIBUTION DES HIDRATES DE CARBONE ET DES LIPIDES PENDANT UN EXERCICE PROGRESSIF AVEC UN PACIENT DIABÉTIQUE TYPE II

RÉSUMÉ

La mobilisation et l'usage des substrats endogènes durant l'exercice sont importants pour le approvisionnement d'energie et performance. Dans le diabète mellitus type 2 (T2D), le choix convenient d'intensité pour l'entraînement afin d'optimiser l'oxidation des graisses reste une controverse. L'objectif de cet étude était de rechercher les effects d'un protocole d'exercice progressif dans un pacient T2D, en montrant le pourcentage de contribution des hydrates de carbone et des lipides afin de fournir l'energie musculaire dans des diferentes niveaux d'intensités a travers la méthode de mesure calorique indirècte. L'étude de cas du type transversal a été conduit avec un pacient T2D, du sexe masculine, age de 59 ans, hauteur de 1,73 ms, et avec un poids de 101,2 kgs; et um índice de masse corporel (IMC, kgm-2) de 33,81; glycemie à jeun (mmol L-1) de

8,8. Ce pacient exerce peu d'activité physique et ne participe pas à des programmes de entraînement physique. Les resultats sugèrent que la prescription d'exercice avec une intensité de 45-50% du VO 2 peak (8,5mL/Kg/min) pour optimiser la consommation de graisse dans um pacient T2D.

MOTS CLEFS: Diabète mellitus type 2; mesure calorique indirècte; hidrates dês carbone; lipides, exercice.

PORCENTUAL DE CONTRIBUCIÓN DE CARBOHIDRATOS Y LIPIDIOS DURANTE EJERCICIO PROGRESIVO EN PACIENTE CON DIABETIS TIPO II

RESUMEN

La movilización y el uso de sustratos endógenos durante el ejercicio son importantes para el fomento de la energía y del performance. En la diabetes mellitos tipo 2 (T2D), la elección adecuada de intensidad para el entrenamiento para optimizar la oxidación de grasas permanece en controversia. El objetivo de este estudio fue investigar los efectos de un protocolo de ejercicio progresivo en un paciente T2D, señalando el porcentual de contribución de carbohidratos y de lipidios para el suprimento energético muscular en distintas intensidades por el método de calorimetría indirecta. El estudio del caso del tipo transversal fue hecho con un paciente T2D, del sexo masculino, 59 años, midiendo l,73m y pesando 101,2 kg, con un índice de masa corporal (IMC, kgm): 33.8l; glicemia de desayuno (mmol L): 8.8. Este paciente es poco activo y no estaba participando de otro programa de entrenamiento físico. Los resultados sugieren que la prescripción de ejercicio con intensidades de 45-50% del VO (8,5 ml/kg/min) para optimizar el consumo de grasas en paciente T2D.

PALABRAS CLAVE: Diabetes mellitas tipo 2, calorimetría indirecta, carbohidratos, lipidios y ejercicio.

PERCENTUAL DE CONSUMO DE CARBOIDRATOS E LIPÍDEOS DURANTE EXERCÍCIO PROGRESSIVO EM PACIENTE DIABÉTICO TIPO II

RESUMO

A mobilização e o uso de substratos endógenos durante o exercício são importantes para o fornecimento de energia e performance. No diabetes *mellitus* tipo 2 (T2D), a escolha adequada de intensidade para o treinamento para otimizar a oxidação de gorduras permanece controvérsia. O objetivo deste estudo foi investigar os efeitos de um protocolo de exercício progressivo em um paciente T2D, mostrando o percentual de contribuição de carboidrato e lipídeos para suprimento energético muscular em diferentes intensidades pelo método de calorimetria indireta. O estudo de caso do tipo transversal foi conduzido com um paciente T2D, do sexo masculino, idade: 59; estatura (cm): 173; peso (kg): 101.2; índice de massa corporal (IMC, kgm^{-2}): 33.81; glicemia de jejum (mmol L^{-1}): 8.8. Este paciente é pouco ativo e não estava participando de outro programa de treinamento físico. Os resultados sugerem que a prescrição de exercício em intensidades de 45-50% do VO_{2pico} (8,5 mL/kg/min) para otimizar o consumo de gordura em paciente T2D.

PALAVRAS-CHAVE: Diabetes *mellitus* tipo 2; calorimetria indireta; carboidrato; lipídeos, exercício.