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Physical exercise and type 2 diabetes mellitus

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ABSTRACT

Introduction: Type 2 diabetes mellitus is considered to be an epidemic in the 21st century. The beneficial effect produced by physical exercise in the management of these patients is well known.

Objective: To determine the effect of physical exercise in type 2 diabetes mellitus patients who were included in a rehabilitation program, characterize the evolution of the associated risk factors and modify some biochemical and exercise test parameters.

Method: An intervention study was conducted in 50 diabetic patients who were included in a rehabilitation program. Each patient underwent physical examination; and blood glucose, cholesterol and triglycerides tests were performed at the beginning of the program and every 6 months during a 24-month period. At the end of each semester, an exercise test was performed according to the Bruce protocol.

Results: There was a predominance of female patients (29/50, 58%), white skin patients (48%) and those aged 35-59 years (60.0%). Control of hypertension was achieved in all affected cases, as well as elimination of the sedentary lifestyle. Smoking decreased from 34 to 8.2%. In addition, there was a significant reduction in the average blood glucose levels (5.8 ± 1.0), glycosylated hemoglobin (5.9 ± 1.0) and triglycerides (1.7 ± 0.4).

Conclusions: In the diabetic patients of the study, the control of the disease and its associated risk factors improved; and some parameters of the exercise test also improved.

Key words: Type 2 diabetes mellitus, Cardiovascular rehabilitation, Physical training, Coronary risk factors

Ejercicio físico y diabetes mellitus tipo 2

RESUMEN

Introducción: La diabetes mellitus tipo 2 está considerada como una epidemia del siglo XXI, es bien conocido el efecto beneficioso que produce el ejercicio físico en el tratamiento de estos pacientes.

Objetivo: Determinar el efecto del ejercicio físico en los pacientes con diabetes mellitus tipo 2 incluidos en un programa de rehabilitación, caracterizar la evolución de los factores de riesgo asociados y modificar algunos parámetros bioquímicos y ergomé-

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tricos.

Método: Se realizó un estudio de intervención en 50 pacientes diabéticos incluidos en un programa de rehabilitación. A cada uno se le realizó examen físico, así como análisis de glucemia, colesterol y triglicéridos al inicio del programa y a intervalos de 6 meses hasta los 24 meses. Al culminar cada semestre, se realizó una prueba ergométrica evaluativa, según el protocolo de Bruce.

Resultados: Predominaron los pacientes del sexo femenino (29/50, 58 %), color blanco de piel (48 %) y edad entre 35-59 años (60,0 %). Se logró el control de la hipertensión arterial y el sedentarismo en todos los casos afectados, y el tabaquismo se redujo de 34 a 8,2 %. Además, se redujeron significativamente los valores promedio de glucemia (5,8 ± 1,0), hemoglobina glucosilada (5,9 ± 1,0) y triglicéridos (1,7 ± 0,4).

Conclusiones: En los pacientes diabéticos estudiados se logró mejorar el control de su enfermedad y de los factores de riesgo asociados, y se modificaron favorablemente algunos parámetros de la ergometría.

Palabras clave: Diabetes mellitus tipo 2, Rehabilitación cardíaca, Entrenamiento físico, Factores de riesgo coronario

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has become an epidemic in the 21st century, both in Western countries and in the Third World[1]. In 2010, the total number of diabetic patients worldwide exceeded 200 million, and epidemiological estimates of the World Health Organization predict they will reach 366 million (4.4% of the world population) by 2030[2].

It is well known that T2DM is a syndrome characterized by generalized metabolic disorders, in which the dominant factor is a chronic hyperglycemia[3]. Insulin resistance is a pathophysiological characteristic of T2DM, which is linked with other comorbidities such as hypertension, obesity, excessive intake of saturated fat and physical inactivity, which are interrelated and affect the prognosis of the patient[4-6]. Furthermore, due to the microvascular and macrovascular damage that takes place, the majority of diabetic patients die of cardiovascular disease, being atherosclerosis responsible for 80% of cases[7].

According Jennings *et al*[8], multiple studies have shown that routine physical activity (i.e., physical exercise) provides health benefits mainly in diabetic patients, due to an increase in the activity and mitochondrial content of the skeletal muscle; which provides an additional mechanism that improves the sensitivity to insulin, produced by exercise, as well as a better control of glycemia levels, which helps reduce cardiovascular complications.

Despite the known beneficial effects of rehabilitation programs, only 25% or less of patients who are advised to participate take part in these programs. A fact that is related to the lack of awareness of the patient in relation to their condition and the limited information provided by the specialist about the need for the implementation and compliance with these programs[9].

At the Hermanos Ameijeiras Hospital, there is a Cardiovascular Rehabilitation Department that has increased its number of patients and has achieved good results in clinical progress. It has improved the psychosocial profile of patients and made possible a rapid return to work.

This study, which will open a broad field of study on the effects of exercise in the patients treated at this hospital, and which will allow the development of strategies to improve the care provided, improve the quality of life and improve the prognosis of the underlying disease, was conducted in order to determine the effect of physical exercise in patients with T2DM who were included in a rehabilitation program, characterize the evolution of the associated risk factors and modify some biochemical and exercise test parameters.

METHOD

An intervention study was conducted with all diabetic patients who were referred to the Department of Exercise Testing and Rehabilitation of the Hermanos Ameijeiras Surgical Hospital, from January 2010 to November 2012.

The sample consisted of 50 patients who agreed to participate in the study and signed the informed consent model.

Inclusion criteria

Patients with a diagnosis of T2DM who were referred to the Department of Exercise Testing and Rehabilitation of the hospital, and who completed the entire rehabilitation program for 24 months.

Exclusion Criteria

Patients who were not eligible for the physical training program or who had cardiovascular, orthopedic or psychiatric conditions that would cause interruption of the training program.

All patients underwent physical examination and blood glucose, cholesterol and triglycerides tests at the beginning and every 6 months during a 24-month period. The rehabilitation program included training sessions from 30 to 130 minutes, with a weekly frequency (it included calisthenics such as cycling, ramp, jogging, squats, and crunches, supervised by the rehabilitation technician and the cardiologist responsible for this activity). At the end of each semester, an exercise test was performed using the Bruce protocol.

A questionnaire form was devised for collecting and summarizing the variables of interest, according to the interview and the information contained in the medical record. This information was entered into a database created in SPSS version 16.0. Percentage was used as a summary measure for qualitative data, as well as the median and standard deviation for quantitative data. Contingency tables were created, with the use of nonparametric chi-square test, in order to determine the level of statistical significance of associated probability. It was considered significant when $p < 0.05$.

The results are presented in tables and charts.

RESULTS

Table 1 shows the prevalence of patients from the age group 35-59 years (60.0%), and females (29/50, 58%). There was also a predominance of white skin patients (48%) (**Figure 1**).

At the start of the rehabilitation program, 90% of diabetic patients had hyperglycemia (**Table 2**), and this percentage decreased significantly (26.5%, P <0.05) at 24 months. The other risk factors under study had a similar behavior, since all of them showed improvement after the intervention, and the sedentary lifestyle and hypertension were completely controlled.

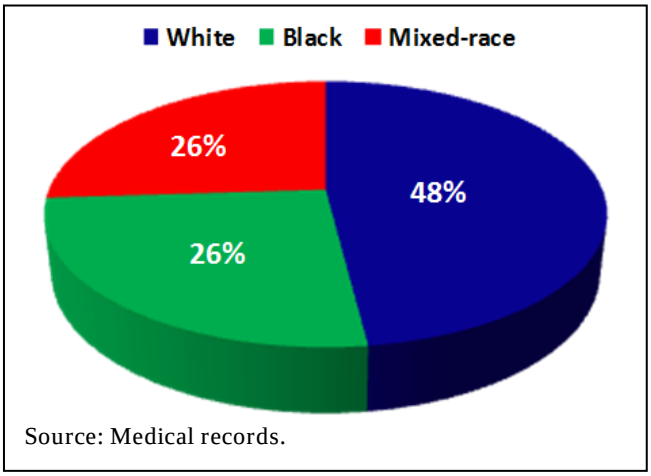
Table 3 shows the reduction in the mean values of biochemical variables during the training phases, which was more evident in blood glucose (8.1 ± 1.7 vs. 5.8 ±

Table 1. Age groups and sex of rehabilitated patients.

Age groups (years)	Sex				Total	
	Female		Male			
	Nº	%	Nº	%	Nº	%
35 - 59	19	65,5	11	52,4	30	60,0
60 - 65	5	17,2	4	19,0	9	18,0
Over 65	5	17,2	6	28,6	11	22,0
Total	29	100	21	100	50	100

Source: Medical records.

Figure 1. Color of skin of rehabilitated patients.



Source: Medical records.

Table 2. Behavior or associated RF at the beginning and end of the RP.

Risk factors	Before		After		p value
	Nº	%	Nº	%	
Hyperglycemia	45	90,0	13	26,5	0.0341
Sedentary lifestyle	50	100	0	0,0	0.0020
Hypertension	45	90,0	0	0,0	0.0010
Dyslipidemia	43	86,0	5	10,2	0.0124
Smoking	17	34,0	4	8,2	0.0014
Obesity	29	58,0	11	22,4	0.0148

Source: Medical records.

1.0 mmol/L; p = 0.0025), glycosylated hemoglobin (8.0 ± 1.0 vs. 5.9 ± 1.0%; p = 0.0040) and triglycerides (3.2 ± 1.1 vs. 1.7 ± 0.4 mmol/L, p = 0.0012). Similar situation was achieved with the exercise test variables (**Table 4**), that show a significant increase in the mean values of myocardial oxygen consumption (22.1 ± 1.5 vs. 24.6 ± 1.4%; P = 0.0016) and energy consumption (6.2 ± 0.5 vs. 7.1 ± 0.4 MET; p = 0.0028), and reduced systolic blood pressure (131.5 ± 8.8 vs. 105.5. ± 15.6 mmHg; p = 0.1058), diastolic blood pressure (83.4 ± 8.7 vs. 67.5 ± 5.0 mmHg; p = 0.1257) and heart rate (73.4 ± 9.4 vs. 60 6 ± 6.3 bpm; p = 0.5628).

DISCUSSION

Our results agree with those found by Boule *et al*[10], in a study on the effect of physical exercise in patients with T2DM, where the mean age was 55 ± 5 years and there was a predominance of female patients (43%)[11].

Although few studies have addressed the skin color in this context, a predominance of white skin has been reported. The results of these studies[11-13] agree with our finding that most patients are white; however, it is recognized that this variable depends on the ethnic characteristics of the population under study.

Other authors[14-16] have also managed to reduce the total number of sedentary and hypertensive patients as the main result of the rehabilitation program. This again demonstrates the benefits attributed to physical exercise, which is the cornerstone for achieving better results in the control of T2DM, as well as other associated risk factors[17]. There was a significant reduction in the number of smokers, which may be related to the educational work done by cardiologists and the rehabilitation specialist, by providing lectures on the harmful effects of this toxic habit and strategies to eradicate it.

Physical exercise improves the metabolic control of blood glucose, glycosylated hemoglobin and lipids; including increased serum levels of high density lipoproteins[18]. This determines a marked decrease in insulin resistance and promotes the improvement of the anti-inflammatory markers, reducing the microvascular and macrovascular complications of the diabetic patients.

In this study, we were able to find such effects, although other authors[19,20] have not found them; something that might be related to the small number of patients and the poor adherence to the exercise program.

It was noticed that, as the rehabilitation program progressed, the average values of myocardial oxygen consumption and energy consumption increased.

Table 3. Biochemical variables in relation to the time of the RP.

Variables (mmol/l)	Mean ± standard deviation					Valor de p
	Baseline	6 months	12 months	18 months	24 months	
Glycemia	8,1 ± 1,7	7,6 ± 1,5	7,0 ± 1,3	6,5 ± 1,2	5,8 ± 1,0	0.0025
LDL cholesterol	3,0 ± 0,5	2,8 ± 0,4	2,4 ± 0,4	2,1 ± 0,3	1,8 ± 0,2	0.1242
HDL cholesterol	0,8 ± 0,1	0,9 ± 0,1	1,0 ± 0,2	1,1 ± 0,2	1,2 ± 0,2	0.1005
Total cholesterol	6,4 ± 0,9	6,1 ± 0,9	5,6 ± 0,9	5,1 ± 0,9	4,5 ± 0,9	0.1245
Triglycerides	3,2 ± 1,1	3,0 ± 0,9	2,6 ± 0,8	2,1 ± 0,6	1,7 ± 0,4	0.0012
Glycosylated Hb (%)	8,0 ± 1,0	7,6 ± 1,0	7,1 ± 1,0	6,5 ± 1,0	5,9 ± 1,0	0.0040

Source: Medical records. Hb: Hemoglobin, LDL: Low-density lipoprotein, HDL: High-density lipoprotein

Table 4. Exercise test variables in relation to time of the RP.

Variables (mmol/l)	Mean ± standard deviation					p value
	Baseline	6 months	12 months	18 months	24 months	
SBP (mmHg)	131,5 ± 8,8	127,1 ± 8,1	120,8 ± 8,2	114,8 ± 7,4	105,5 ± 15,6	0.1058
DBP (mmHg)	83,4 ± 8,7	81,4 ± 7,7	75,8 ± 7,0	71,5 ± 6,3	67,5 ± 5,0	0.1257
Heart rate (bpm)	73,4 ± 9,4	70,7 ± 8,5	67,4 ± 7,8	63,9 ± 8,2	60,6 ± 6,3	0.5628
VO2 Max (%)	22,1 ± 1,5	22,6 ± 1,4	23,2 ± 1,4	23,8 ± 1,4	24,6 ± 1,4	0.0016
Energy consumption (METs)	6,2 ± 0,5	6,4 ± 0,5	6,6 ± 0,4	6,8 ± 0,5	7,1 ± 0,4	0.0028

Source: Medical records.

This improvement in functional capacity is closely related to the correct implementation of the physical training, following the method of intervals and complying with its principles properly[21].

Our results were similar to those found by Chudyk and Petrella[22], who believe that the improvement in cardiorespiratory fitness and exercise tolerance lead to beneficial hemodynamic and metabolic results. Conversely, Bhattacharyya *et al*[23], in their study, found no beneficial results, because when using a resistance exercise protocol in diabetic patients, no change occurred in the chemical and hemodynamic variables under study.

For a rehabilitation program to be effective, in type 2 diabetes, it should include exercises of moderate intensity and a high level of strength training, in order to achieve an improvement in cardiorespiratory fitness, muscle strength and the different physiological and biochemical parameters[24].

CONCLUSIONS

After the rehabilitation program in patients with T2DM, it was possible to improve the control of their disease and the associated risk factors.

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