Impact of Postural Corrective Training (TCP®) on overall glycemic control in diabetic middle-aged women

Impacto do treinamento corretivo postural (TCP®) no controle glicêmico geral em mulheres diabéticas de meia-idade

Impacto del entrenamiento correctivo postural (TCP®) en el control glucémico general en mujeres diabéticas de mediana edad

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Abstract
Introduction: Diabetes mellitus (DM) is a disease manifested by chronic hyperglycemia resulting from changes in the secretion and / or action of insulin, which can cause tissue damage. The practice of physical exercise is often recommended in the treatment of this disease because it improves glucose uptake due to increased insulin sensitivity. Objective: to evaluate the effect of Corrective Postural Training (TCP®) on the glycemic metabolism of patients with type 2 diabetes. Methods: Twenty-one women between 44 and 55 years old were divided into four groups: sedentary diabetics (SD); exercised diabetics (ED); non-diabetic exercised (NE); and non-diabetic sedentary (NS). TCP® was performed 3 times / week, for 1 hour / day, for a period of 20 weeks. Blood samples were collected pre- and post-intervention to determine cholesterol, triglycerides, HDL, fasting glycemia, glycated hemoglobin, estimated mean glycemia and cortisol. The Wilcoxon and Friedman tests were used to compare the results before and after intervention. Results: there was no significant difference in the anthropometric, biochemical and hormonal variables of all groups; however, glycated hemoglobin showed a significant difference (p <0.05) in the ED group after 20 weeks. Important intragroup clinical changes were observed with return to the reference values of some of the analyzed parameters. Conclusion: The TCP® method may have contributed to the improvement of plasma levels of glycated hemoglobin in the ED group in addition to the clinical improvement of patients.
Keywords: Diabetes complications; Exercise; Glycated Hemoglobin A; Cortisol.

Resumo
Introdução: O Diabetes mellitus (DM) é uma doença manifestada por hiperglicemia crônica decorrente de alterações na secreção e/ou ação da insulina, podendo causar danos aos tecidos. A prática de exercício físico é amplamente recomendada no tratamento desta doença por melhorar a captação de glicose devido ao aumento da sensibilidade à insulina. Objetivo: avaliar o efeito do Treinamento Postural Corretivo (TCP®) no metabolismo glicêmico de pacientes com diabetes tipo 2. Métodos: Vinte e uma mulheres de 44 a 55 anos foram divididas em quatro grupos: diabéticas sedentárias (SD); diabéticas exercitadas (ED); não diabéticas exercitadas (NE); e não diabéticas sedentárias (NS). O

TCP® foi realizado 3 vezes/semana, durante 1 hora/dia, por um período de 20 semanas. Amostras de sangue foram coletadas pré e pós-intervenção para determinação de colesterol, triglicerídeos, HDL, glicemia de jejum, hemoglobina glicada, glicemia média estimada e cortisol. Os testes de Wilcoxon e Friedman foram usados para comparar os resultados pré e pós-intervenção. Resultados: não houve diferença significativa nas variáveis antropométricas, bioquímicas e hormonais de todos os grupos; porém a hemoglobina glicada apresentou diferença significativa (p <0,05) no grupo DE após 20 semanas. Foi observado alterações clínicas importantes intragrupos, com retorno aos valores de referência de alguns dos parâmetros analisados. Conclusão: O método TCP® pode ter contribuído para a melhora dos níveis plasmáticos de hemoglobina glicada no grupo DE além da melhora clínica das pacientes.
Palavras-chave: Complicações do diabetes; Exercício físico; Hemoglobina A Glicada; Cortisol.

Resumen
Introducción: La diabetes mellitus (DM) es una enfermedad que se manifiesta por hiperglucemia crónica resultante de cambios en la secreción y/o acción de la insulina, que puede ocasionar daño tisular. La práctica de ejercicio físico es ampliamente recomendada en el tratamiento de esta enfermedad para mejorar la captación de glucosa debido al aumento de la sensibilidad a la insulina. Objetivo: evaluar el efecto del Entrenamiento Postural Correctivo (TCP®) sobre el metabolismo glucémico de pacientes con diabetes tipo 2. Métodos: Veintiuna mujeres de 44 a 55 años fueron divididas en cuatro grupos: diabéticas sedentarias (SD); diabéticos ejercitados (ED); no diabético ejercitado (NE); y sedentarios no diabéticos (NS). El TCP® se realizó 3 veces/semana, durante 1 hora/día, durante un período de 20 semanas. Se recolectaron muestras de sangre antes y después de la intervención para la determinación de colesterol, triglicéridos, HDL, glucosa en sangre en ayunas, hemoglobina glicosilada, glucosa en sangre media estimada y cortisol. Se utilizaron las pruebas de Wilcoxon y Friedman para comparar los resultados antes y después de la intervención. Resultados: no hubo diferencia significativa en las variables antropométricas, bioquímicas y hormonales en todos los grupos; sin embargo, la hemoglobina glicosilada mostró una diferencia significativa (p <0,05) en el grupo de DE después de 20 semanas. Se observaron cambios clínicos intragrupo significativos con retorno a valores de referencia de algunos de los parámetros analizados. Conclusión: El método TCP® puede haber contribuido a la mejora de los niveles plasmáticos de hemoglobina glicosilada en el grupo DE, además de la mejora clínica de los pacientes.
Palabras clave: Complicaciones de la diabetes; Ejercicio físico; Hemoglobina A Glucada; Cortisol.

1. Introduction

Diabetes mellitus (DM) is a disease characterized by hyperglycemia. The most common types of diabetes are type 1 diabetes (DM1), in which an absolute insulin deficiency occurs due to the destruction of pancreatic beta cells and, type 2 diabetes (DM2), where insulin resistance can lead to hyperglycemia ("Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetesd2018," 2018). The prolonged exposure to high concentrations of glucose promotes tissue damage leading to progressive loss of function (Sociedade Brasileira de Diabetes, 2018). In addition, changes in glucose metabolism predispose to increase the cardiovascular disease risk (Pedersen & Saltin, 2015; Stumvoll et al., 2005). Metabolic dysregulation and chronic inflammation are considered responsible for increase in cardiovascular morbidity and mortality of the DM2 patients. Thus, mitigating metabolic dysfunction and preventing inflammation should be a priority (Karstoft & Pedersen, 2016). In this way, changes in lifestyle and regular exercise effectively provide a strong stimulus for improving both.

Aerobic exercise associated with a regular diet leads to benefits in DM2 control by maintaining blood glucose at normal levels (Andersson et al., 2005), decreasing adiposity, increasing the insulin action (Ishikawa-Takata et al., 2003), improving the lipid profile (Mogharnasi et al., 2019) and reduces cardiovascular events and mortality (Karstoft & Pedersen, 2016). Therefore, physical exercise is using as a treatment and prevention to attenuate the metabolic impairments from DM2 and obesity.

Nevertheless, attention is required when prescribing physical exercise to DM2 individual, since factors as frequency, intensity and type of exercise (aerobic/anaerobic) may produce excess of the free radicals (He et al., 2016). Free radicals are highly reactive molecules that lead to oxidative stress (Dehghan et al., 2008). It is known that both oxidative stress and chronic inflammation are associated with the development of metabolic diseases, which includes diabetes (Newsholme et al., 2016). The increase in the level of oxidative load, associated with DM2, can lead to oxidative damage to cell membranes and cell constituents and contributes to inflammation and vascular dysfunction (Newsholme et al., 2016). The increase of systemic

stress as in high intensity exercise in diabetes can intensify the damage of diabetes (Zanella et al., 2007).

In this context, aerobic training is extensively recommended for patients with DM2.The Corrective Postural Training (TCP®) is an aerobic modality of physical exercise, developed by adding scientific knowledge in sports training, biomechanics, postural control and functionality. TCP® has been suggested as a new training method and is characterized by the actions of the upper and upper limbs, with the overload of the body segments and gravitational action, which the individual will move in pre-defined planes and axes along the path (de Lima et al., 2018; Duarte, 2012). Through movements in different angles and amplitudes, planes in the frontal and sagittal planes, of dynamic and isometric contractions, it aims at the biomechanical balance between internal and external forces (Duarte, 2012). As it is a new modality, studies on the effects of this type of physical exercise on DM2 control are beginning.

Therefore, the aim of this study was to verify the effect of aerobic physical exercise (TCP®) modality, on metabolic parameters such as cortisol, fasting glycaemia, lipid profile and glycated hemoglobin (HbA1c) profile of patients with DM2.

2. Methodology

Subjects

This research was approved in the Human Research Ethics Committees of the Federal University of São Carlos – SP (CAAE: 06890412.1.00005504). The volunteers were recruited by Diabetes Attention Program (PAD)/UFSCar and Academies of Sports Practices, in the city of São Carlos-SP.

Twenty-one volunteers were enrolled in this study and composed of 4 groups: sedentary diabetic women (SD/ n=5); exercised diabetic women (ED/ n=5); non-diabetic sedentary women (NS/ n=5); and non-diabetic exercised women (NE/ n=6). The personal and general data of the volunteers were collected using the International Physical Activity Questionnaire (IPAQ) (de Lima et al., 2018). This questionnaire allows to determine the degree of physical activity and physical inactivity and to evaluate the food record of each volunteer. The volunteers underwent general health screening and must satisfy all the following criteria to be eligible for the study: women aged between 44 years and 55 years old; diabetic and non-diabetic patients; without respiratory and cardiac problems, exercised and not exercised. The volunteers received orientation on food care from the nutritionist.

TCP® protocol

Aerobic physical exercise occurred at the Unit of Health School (USE) and Physical Conditioning Laboratory at the Federal University of São Carlos (UFSCar). The methodology used was the Postural Corrective Training (TCP®), based in the natural and functional movements, carried out simultaneously and coordinate. Each TCP® session lasted for 60 minutes. The muscle activity, in this method, is harmonically standardized with acyclic and low impact movements, performed predominantly in the frontal plane (Newsholme et al., 2016; Zanella et al., 2007). The training was applied three days a week for 60 minutes, intensity and heart rate around 70% (220 - age) (Duarte, 2012; Nathan et al., 2008). The physical activity had been monitored using a specific form.

Anthropometric Assessment

The anthropometric data were assessed in two moments: before the beginning of the interventions and after 20 weeks, end of experimental period. The evaluated parameters were weight (kg), carried out using the electronic scale (Toledo- model 2096-pp) with the graduation of 5 grams until 150 kg; height (m) collect using a non-flexible metallic anthropometer (Toledo) 0,05 cm graduation. Body Mass Index (BMI) was calculated by weight (kg) divided by height (m) squared (kg/m2); abdominal circumference, using a measuring tape graduated accurately in centimeters (cm) and percentage (%) of fat it was performed

through of bioimpedance electronic scale (Tanita, model 2001).

Biochemical and hormonal assessment

Volunteers blood was collected after 12 hours of fasting, before starting interventions and after the 20 weeks of interventions. A tube with heparin anticoagulant was used for both lipid and glucose profile, standardized for all groups. The plasma was quickly separated in a centrifuge (Fanem – Excelsa Baby 1) at 3500 rotation per minute (rpm) for 10 minutes. The samples were kept in a freezer at -20°C until the day of analysis. For Glycated Haemoglobin (HbA1c) analyses, the blood was collected in a tube containing EDTA anticoagulant by turbidimetric method. This is the "gold standard" method for controlling blood glucose in diabetic patients. This analysis was performed in the laboratory of Unimed (Unilab in São Carlos city) by turbidimetric method.

The estimated mean value of glucose (eAG) was determined by a mathematical equation using the values obtained from HbA1c (Nathan et al., 2008). This calculation determines the average blood glucose for the last three months, in mg / dl, regardless of diet and daily physical activities.

The total cholesterol (TC), triglycerides, and fasting glucose were quantified using a Kit (Laborclin/biodiagnostic), according to the descriptions of the manufacturer. The Cortisol, was quantified in the laboratory of Unimed (Unilab), using the chemiluminescence method, with the reference values of 4.0 to 22.40 μg/dl.

Statistical analysis

Statistical analysis was performed using the program Sigma stat version 3.5. The significance level was set up at $p < 0.05$. The Shapiro Wilk test was applied to assess the assumption of normality for the data. Parametric data were expressed as mean ± standard deviation (SD). Non-parametric data the Wilcoxon and Friedman test was performed. Comparing the delta values was performed by t test independent by groups. The delta values were obtained from the formula: Δ= (final value - initial value) / initial value.

3. Results

The Table 1 shows the results of the IPAQ questionnaire and anamnesis evaluation. The volunteers were diabetic from 2 to 23 years old. Among the 21 volunteers, 17 were in the climacteric, 10 volunteers were using hypotensive drugs, 8 using metiformin, 2 insulin, 1 glyphage and 10 volunteers were taking hormone replacement. Fourteen volunteers had a family history of hypertension, 3 brain strokes, 7 obesity and 2 cardiovascular diseases.

Table 1 – Medical history according to the IPAQ questionnaire and anamnesis evaluation.

IPAQ questionare and anamnsesis		NS (n=5)	NE (n=5)	SD (n=5)	ED (n=6)
Diabetes duration		-------	-------	2 up to 10 years	2 up to 23 years
Addictions	Cigaretes	40%	-------	-------	20%
	Alcoholic beverages	-------	-------	20%	-------
Osteoarticular problems		-------	-------	20%	20%
Use of medication	Glycemia	-------	-------	Metformin 60%	Glifage 20%
		-------	-------	Insulin 40%	Metformin 80%
	Hypotensive	0%	16,70%	80%	80%
	Hormone therapy	20%	50%	20%	80%
	Climacteric fase	100%	33,40%	60%	100%
Family history	Hypertension	80%	50%	40%	100%
	Brain stroke	40%	3,40%	20%	0%
	Obesity	20%	6,70%	20%	60%
	Cardiovascular disease	0%	0%	0%	40%

NS: normal sedentary, NE: normal exercised; SD: sedentary diabetic; ED: exercised diabetic. Source: Research Data.

After 20 weeks of intervention, there was no significant difference between the groups for all anthropometric variables (Table 2). However, when we evaluated the delta, we noticed that there was a slight reduction in the body mass, BMI, fat (%) and waist circumference in the ED, SD and NS groups (Table 2). Specially in the NE group, it was evidenced that almost all the variables presented increase, except the waist circumference that reduced.

The modulation of the total cholesterol, HDL, glycemia, trycycerides and cortisol after 20 weeks of the interventions were expressed in the Table 3. The delta of the total cholesterol increased in the SD, NS and NE groups. Contrary to the previous groups, the ED presented a decrease in this same parameter. The delta HDL increased in the SD and NE groups, but decreased in the ED and NS groups. Elevation was observed in the delta values for triglycerides of the SD group, but the opposite occurred in the other groups, which obtained reduction and, in the ED group, was more noted. The fasting glycemia delta values showed increased in the SD, NE and NS groups and reduction in ED group. There was an increase in cortisol levels, in all groups specifically in the ED group.

Table 2 - Anthropometric variables.

Variables	Groups											
	NS			NE			SD			ED		
	Baseline	Final	Δ Value (%)	Baseline	Final	Δ Value (%)	Baseline	Final	Δ Value (%)	Baseline	Final	Δ Value (%)
Body weight (Kg)	70.24±8.03	69.68±8.26	- 0.79	60.90±7.25	61.33±7.59	0.63	104.74±7.41	102.80±7.17	- 1.83	72.96±11.54	72.16±11.83	- 1.09
BMI (Kg∕cm²)	27.73±3.26	27.50±3.40	- 0.82	23.47±2.35	23.60±2.35	0.67	38.73±3.75	38.00±3.80	- 1.82	27.22±3.04	26.90±4.07	- 1.05
% fat	36.20±5.12	36.80±5.63	1.57	29.50±6.53	30.80±4.91	**5.82**	47.80±3.70	47.60±4.57	- 0.40	37.60±4.73	37.00±4.47	**- 1.51**
Abdominal circumference (cm)	87.80±11.70	86.60±12.70	- 1.42	80.50±6.41	79.00±8.60	**- 1.97**	121.00±6.40	115.00 ±7.93	- 4.96	94.40±6.58	87.60±12.3	**- 7.20**

Values expressed by mean ± SD. * Statistical difference between baseline value. NS: normal sedentary, NE: normal exercised, SD: sedentary diabetic; ED: exercised diabetic. BMI: Body mass index.
Source: Research Data.

Table 3 – Lipid profile, hormonal parameters, glycated haemoglobin and estimated average glucose parameters.

Variables	Groups											
	NS			NE			SD			ED		
	Baseline	Final	Δ value (%)	Baseline	Final	Δ value (%)	Baseline	Final	Δ value (%)	Baseline	Final	Δ value (%)
Total cholesterol (mg/dl)	162.8±45.0	189.3±31.5	17.2	179.8±25.7	203.7±17.6	14.8	189.9±22.5	220.8±50.4	17.5	168.6±28.9	173.5±83.5	3.97
HDL (mg/dl)	40.7±7.39	39.8±5.77	-2.21	51.3±7.66	56.8±7.53	11.5	39.2±5.98	39.7±4.68	1.76	48.1±14.0	47.1±12.4	-2.18
Triglycerides (mg/dl)	122.0±43.1	104.4±68.3	-4.06	93.0±23.7	80.1±32.4	-6.13	259.9±134.8	291.8±178.2	28.9	129.0±104.7	82.3±37.8	-10.2
Glycemia (mg/dl)	92.0±11.9	95.3±8.76	1.45	91.2±10.6	92.2±9.52	4.07	189.8±66.8	203.2±46.6	17.0	138.6±83.3	118.3±26.6	-4.21
Cortisol (µg/dl)	14.9±6.18	18.9±9.46	22.3	16.8±4.18	17.9±3.36	11.9	16.7±6.26	17.9±4.59	22.1	13.9±4.64	18.5±3.8	45.8

Values expressed by mean ± SD. * Statistical difference between baseline values. NS: normal sedentary, NE: normal exercised, SD: sedentary diabetic; ED: exercised diabetic; %: percentage; Δ: Delta; mg/dL: milligram per decilitre; µg/dL: microgram per decilitre. References values: total cholesterol: < 200 mg/dl; HDL: female >50 mg/dl; Triglycerides: < 150 mg/dL; baseline glycaemia: 70 to 100 mg/dl; Cortisol: Between 7 and 9 am: 5.4 to 25.0 µg/dL; between 4 and 5 pm: 2.4 to 13.6 µg/dL. Source: Research Data.

The figure 1A and 1C shows that the exercise TCP decrease glycated Hb and estimated average glucose variable of the ED group after 20 weeks of training, respectively. Therefore, to demonstrate the individual uniformity of the group in the glycated haemoglobin parameter, the delta was performed (Figure 1B). The relative variation of glycated haemoglobin ($\Delta\%$) the ED group, the patients had a greater reduction. The same happened with the variable eAG ($\Delta\%$) (Figure 1D).

Figure 1 - Glycated haemoglobin and estimated average glucose parameters. (A) Percentage of glycated haemoglobin; (B) Delta of the glycated haemoglobin; (C) Estimated average glucose; (D) Delta of the estimated average glucose.
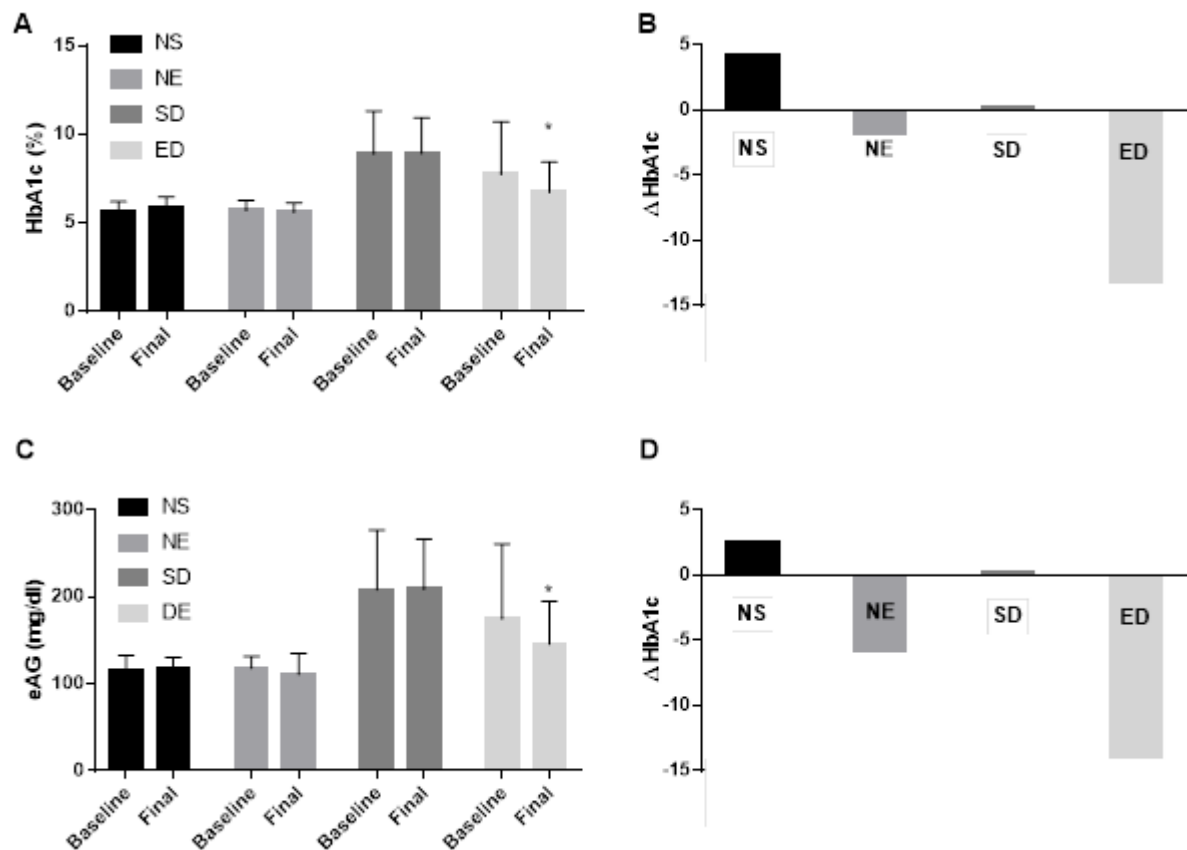
Values expressed by mean ± SD. ∗ Statistical difference between baseline values. NS: normal sedentary, NE: normal exercised, SD: sedentary diabetic; ED: exercised diabetic. HbA1c, glycated haemoglobin; eAG estimated average glucose; %: percentage; Δ: Delta; mg/dL: milligram per decilitre. References values: HbA1c: In the diagnosis of diabetes: Less than 5.7%: low risk of diabetes; Between 5.7 and 6.4%: pre-diabetes; Greater than or equal to 6.5%: diagnosis of diabetes (to be confirmed with second dosage). In the diabetes control: Below 7%: subject to less vascular complications; Greater than 7%: poorly controlled diabetes; eAG: Non-diabetics: 68-126 mg/dL; Diabetes: 140 mg/dL or more. Pre-diabetes: 117-126 mg/dL. Source: Research Data.

4. Discussion

The main finding of this study was to demonstrate that the method of postural corrective training (TCP®) promoted an improvement in the glycemic profile of type 2 diabetic women. It is known that, especially in middle-aged women, physiological and physical changes occur. This phase is called climacteric (Doubova et al., 2011) and is related to menopause and possible increase in the risk of developing obesity (Navarro, 2008). In addition, other associated factors, such as a sedentary lifestyle and inadequate diets, can promote weight gain and the consequent development of DM2 (Raskin et al., 2000).

Physical exercise is the first-line treatment for DM2. There is a consensus that exercise improves metabolic markers

in patients with DM2. In addition, exercise is known to modulate inflammation in an acute and chronic way. Physical exercise has consistently shown improvements in glycemic control, insulin sensitivity, body composition and cardiorespiratory fitness. In addition to having beneficial effects on lipid status and blood pressure, important factors for preventing cardiovascular complications in DM2(Sigal et al., 2007; Umpierre et al., 2011). In fact, in the current study the aerobic exercise TCP®, was important to reduce these parameters mainly in the diabetic group. These findings could represent beneficial clinical changes, as the improve of the metabolic profile due to moderate exercise. It is interesting to note that the improvements observed in the metabolic profile occurred independently of weight loss. Kirvan et al. (2009) observed that in just 7 days of aerobic exercise, in adult patients with DM2, it resulted in improved glycemic control and a 45% increase in the elimination of insulin-stimulated glucose, without any effect on body weight (Kirwan et al., 2009). So, even that the decrease in the BMI and fat percentage were modest, it is an indicative of the effectiveness of the method used, and in agreement with other studies that carried out the structured physical exercise program (Boulé et al., 2001; Vancea et al., 2009).

It is well established in the literature, the importance of reducing waist circumference in the diabetic patient, since there is a positive relationship between this variable with the central obesity, insulin resistance, metabolic syndrome, as well as cardiovascular diseases (Boulé et al., 2001). Thus, reducing waist circumference leads to a decrease in central obesity and improvement of metabolic parameters for diabetic individuals like observed in this study after intervention with the TCP® method, highlighting the benefits of TCP® (Bianchi et al., 2007; Boulé et al., 2001).

It is known that maintaining a physically active lifestyle can reduce the risk of developing impaired glucose tolerance, insulin resistance and DM2. In addition, low cardiovascular fitness is a strong independent predictor of all-cause mortality in patients with DM2. Patients with DM are 2 to 4 times more likely to suffer from cardiovascular disease than healthy individuals, due to the metabolic complexity and also underlying comorbidities of DM2, including obesity, insulin resistance, dyslipidemia, hyperglycemia and hypertension (Kirwan et al., 2017). In this sense, high levels of HbA1c are predictive of vascular complications in patients with diabetes. Regular exercise has been shown to reduce HbA1c levels, both alone and in conjunction with dietary intervention (Kirwan et al., 2017). In the evaluation of a meta-analysis of 9 randomized controlled trials, 266 adults with DM2 performed regular aerobic physical exercises for 20 weeks with 50% to 75% of their maximum aerobic capacity (VO2max). These patients showed significant improvement in HbA1c and cardiorespiratory fitness (Boulé et al., 2003). The greatest reductions in HbA1c were observed with more intense exercise, reflecting in the improvement of blood glucose control. In addition to greater energy expenditure, which helps to reverse DM2 associated with obesity, exercise also increases the action of insulin through short-term effects, mainly through insulin-independent glucose transport. In our study, we observed that it was possible to obtain improvement in HbA1c, eAG and fasting glucose in the diabetic patients, with the TCP® method of moderate aerobic intensity, demonstrating the importance of physical activity for patients with DM2 and the effectiveness of the proposed method. The value of glycated Hb in the diabetic sedentary patients, although not modified, was initially above the reference value. It was verified, thereby, that without the association of physical exercises, there was no reduction of this variable, despite the use of antidiabetic drugs ("Standards of Medical Care in Diabetes-2014," 2014). The persistence of glycated HB values in the non-diabetic patients can be explained by the maintenance of glycemic homeostasis (Leehey et al., 2009), which is equivalent to glycated Hb in the range of normal values from 5.7% to 6.4% ("2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2020," 2020).

Zanella et. al. (2007) concluded that there are controversial opinions regarding the type and intensity of physical exercises that can promote an improvement in lipid metabolism, as well as avoid the excessive formation of free radicals, harmful to tissues, especially of individuals with DM2 (Zanella et al., 2007). In the study by Silva and Lima (2002), moderate and well-directed regular exercise in DM2 was shown to be effective in improving plasma lipid levels, although there was no

significant change in total and LDL cholesterol, as observed in our study (Silva & Lima, 2002). In turn, the increase in total cholesterol observed in non-diabetic patients undergoing TCP® interventions may possibly be justified by the increase in HDL, as in the study by Sposito (2007) (Sposito et al., 2007). However, the increase in total cholesterol in sedentary patients is probably associated with lack of physical exercise, inadequate diet, or both. Zanella et al. (2007), associated the increase in HDL to the high intensity of the exercise and also considered that the more altered the lipid profile, the better the effect of the exercise, raising the HDL fraction and decreasing the fraction, as observed in the non-diabetic exercised group (Zanella et al., 2007). In addition, exercise was effective in improving the plasma triglycerides of diabetic and non-diabetic volunteers, as well as VLDL and LDL (data not shown). It is well described in the literature that well-directed and regularly performed physical exercises reduce triglyceride levels, raising HDL levels (Faludi et al., 2017). In the study by Leehey (Leehey et al., 2009) there was no significant variation in the lipid profile, however, clinical benefits were obtained with moderate aerobic exercise and diet-oriented food, as in this study.

The improvement in the lipid and blood glucose profile of patients with DM2 reflects an improvement in the concentrations of the hormone cortisol. This hormone plays an important role in increasing the levels of markers related to DM2, such as glycemia and glycated hemoglobin, and its increase can lead to hyperglycemia, contributing to the worsening of DM2 (Oltmanns et al., 2006). Its increase may occur due to inadequate lifestyle with high-fat high-carbohydrate diets and sedentary lifestyle, which is reflected in elevated plasma lipids (Wu et al., 2014). High levels of cortisol are also result of a situation of high stress, intense physical exercise, physical effort and hyperglycemia (Bueno, 2011). Thus, it was observed that the hormone cortisol was elevated in all groups, at the end of this study, although within the normal reference values. According to the literature, free radicals produced by exercise depend on factors such as: frequency, intensity, duration and type of exercise adopted [26]. However, as a protection against free radicals produced due to physical exercise, there is the modulation of free cortisol (active form) with cortisol-binding globulin, activating the enzyme that converts cortisol to cortisone (inactive form) (Bueno, 2011), maintaining ideal blood glucose values.

5. Conclusion

We conclude that the TCP® method, applied 3 times a week, accounting for 3 hours of weekly exercise, was effective in maintaining blood glucose in physiological levels, which is the main objective of the treatment of diabetics, and also promoted the reduction of risk parameters for cardiovascular complications. Therefore, this method can be effective strategy for the prevention and treatment for DM2.

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