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Artigo

INTERDISCIPLINARY PROGRAM ASSOCIATED WITH COMBINED RESISTANCE AND AEROBIC PHYSICAL TRAINING INCREASES GLUCOSE TOLERANCE IN OBESE WOMEN AFTER MENOPAUSE

PROGRAMA INTERDISCIPLINAR ASSOCIADO A RESISTÊNCIA COMBINADA E TREINAMENTO FÍSICO AERÓBICO AUMENTA A TOLERÂNCIA À GLICOSE EM MULHERES OBESAS APÓS A MENOPAUSA

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ABSTRACT - Aim: The aim of this study was to evaluate whether the combined physical training is capable of potentializing the effects of a 12 weeks interdisciplinary therapy over glucose tolerance in obese post-menopausal women. **Methods:** Volunteers participated in either a nutritional and psychological interdisciplinary intervention (Inter group, n=10) or the same interdisciplinary intervention associated with combined resistance and aerobic physical training (Inter + PT group, n=19). Anthropometric measures and glucose tolerance, through an Oral Glucose Tolerance Test (oGTT), were determined at baseline and after 12 weeks. **Results:** Improvements were observed on the Body Mass Index (BMI) (p=0.05). Blood glucose at 30 (p=0.011) and 60 minutes (p=0.011) and also the Area Under the Curve (p=0.012) during the oGTT were improved in the Inter + PT group at the end of the intervention. Only the BMI (0.01) and the Body Weight (0.01) were significantly diminished in the Inter Group. There were no statistical

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differences between groups. **Conclusion:** The combined resistance and aerobic physical training is capable to potentialize the effects from an interdisciplinary program improving glucose tolerance in obese post-menopausal women.

Keywords: Interdisciplinary therapy; weight-loss; diabetes; combined training.

RESUMO - Objetivo: O objetivo deste estudo foi avaliar se o treinamento físico combinado é capaz de potencializar os efeitos de uma terapia interdisciplinar de 12 semanas sobre a tolerância à glicose em mulheres obesas na pós-menopausa. **Métodos:** Os voluntários participaram de uma intervenção interdisciplinar nutricional e psicológica (Grupo Inter, n = 10) ou a mesma intervenção interdisciplinar associada ao treinamento físico combinando exercícios resistidos com aeróbios (Grupo Inter + TF, n = 19). As medidas antropométricas e a tolerância à glicose, por meio de um Teste Oral de Tolerância à Glicose (TOTG), foram determinadas no início e após 12 semanas. **Resultados:** Observaram-se melhorias no Índice de Massa Corporal (IMC) (p = 0,05). A glicemia aos 30 (p = 0,011) e 60 minutos (p = 0,011) e também a área sob a curva (p = 0,012), durante o TOTG, foram melhoradas no grupo Inter + PT no final da intervenção. Somente o IMC (0,01) e o Peso Corporal (0,01) diminuíram significativamente no Grupo Inter. Não houve diferenças estatísticas entre os grupos**. Conclusão:** A combinação de exercícios resistidos e aeróbios é capaz de potencializar os efeitos de um programa interdisciplinar melhorando a tolerância à glicose em mulheres obesas na pós-menopausa.

Palavras-chave: Terapia interdisciplinar; emagrecimento; diabetes; treinamento combinado.

INTRODUCTION

Interruption of ovarian function, in addition to decreasing in energy expenditure, reduces the amount of lean mass and stimulates the increase of white adipose tissue, leading to an increased risk of obesity and type 2 diabetes mellitus in postmenopausal

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women [4]. In addition, the current lifestyle with a stimulus to sedentary behavior and inadequate food consumption potentiates the risks of developing obesity and its comorbidities, especially after menopause [5].

On the other hand, physical training associated with changes in nutritional habits is an efficient intervention to improve parameters such as glucose tolerance and to decrease the risk of developing type 2 diabetes mellitus [6]. The benefits related to physical exercise are in its capacity of stimulate the mains glycemic control pathways such as protein kinase B (AKT) and kinase-activated adenosine monophosphate (AMPK) resulting in the GLUT 4 translocation and consequently the increase of glucose tolerance [7].

Although this is a well-established concept, there are still gaps related to the magnitude of the influence of physical training on glucose tolerance, especially when performing interdisciplinary health programs for postmenopausal women. In this context, combined training (aerobic and resistance exercises in the same training session) has shown good results in the control of diabetes and obesity [8], but little is yet known about

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[8] *Ibid*.; MARTINS, Fernanda Maria *et al*, High-intensity body weight training is comparable to combined training in changes in muscle mass, physical performance, inflammatory markers and metabolic health in postmenopausal women at high risk for type 2 diabetes mellitus: A randomized controlled cl, **Experimental Gerontology**, v. 107, n. July 2017, p. 108–115, 2018; EIKENBERG, Joshua D. *et al*, Prediabetes phenotype influences improvements in glucose homeostasis with resistance training, **PLoS ONE**, v. 11, n. 2, p. 1–13, 2016.

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this condition when associated to an interdisciplinary program in postmenopausal women.

Thus, the aim of this research was to evaluate whether combined training is capable of potentiating the effects of an interdisciplinary health program on glucose tolerance in obese postmenopausal women.

METHODS

This study has been approved by the Ethics and Research Committee of the Federal University of São Paulo under No. 1,293,795, CAAE n. 48605915.9.0000.5505 and it was conducted in accordance with the Declaration of Helsinki. All the participants signed the Free and Informed Consent Term and the study was developed according to the National Health Council (Resolution 466/2012).

Sample

Fifty-three women were recruited after dissemination of the program in the local media (newspapers and internet). The inclusion criteria were body mass index (BMI) between 30 and 39.9 kg/m^2, age from 50 to 65 y and being in the menopausal period for at least three months, without hormone replacement and not having participated in physical training in the previous three months. This study did not include volunteers who initiated drug treatment for diabetes or obesity during the protocol.

Study Design

Twenty-nine participants completed the 12 weeks of study. Ten of them were in the interdisciplinary group (Inter) and nineteen participated in the interdisciplinary interventions associated with physical training (Inter + PT group). Body composition, anthropometry and glucose tolerance were measured at baseline and after 12 weeks of therapy.

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Anthropometric assessments

Body mass was determined with a balance, with a maximum capacity of 180 kg and a precision of 100g (CAUDURO®). The height was measured using a stadiometer (Sanny®) fixed to the wall, with an accuracy of 0.01cm.

After taking measurements of total body mass and height, BMI was calculated by dividing body mass (kg) by height (m) squared (kg / m²).

The circumferences of the neck, waist and hip were obtained by means of a simple tape measure of non-elastic tissue as described by Lohman, Roche and Martorell [9].

Oral glucose tolerance test (oGTT)

After at least 48 hours from the end of the program the oGTT was performed. This test consists of measuring fasting capillary blood glucose (12 hours) piercing the skin on the finger and then offering the volunteers 75 grams of anhydrous dextrose, dissolved in 400 ml of water. The glycemia was measured again 30, 60, 90 and 120 minutes after the ingestion of the solution using a glucometer (FreeStyle Lite®). The results were analyzed by means of the determination of the areas below the glucose curves by the trapezoidal method [10].

Combined Physical Training

The physical training was given by trained professionals and occurred 3 times a week, with 25 minutes of aerobic exercise plus 25 minutes of resistance exercise in the same session, with no predetermined order of the type of exercise (random). The volunteers underwent an adaptation period (2 weeks) in addition to the program involving resistance training and walking outdoor in an open environment. Subsequently, the

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estimate of 1 maximal repetition (1RM) was made, based on the Baechle and Groves protocol [11].

The resistance training was carried out, progressively (every three weeks), with loads of 60 and 70% of a 1RM. Right after the sixth week 1RM test was performed again in order to update the loads. The volunteers performed 2 sets of 15 repetitions in the first two weeks and 3 sets of 10 repetitions in the rest of the program. Exercises involving large muscle groups with multiarticular characteristics (horizontal leg press, bench press and front pull down) were made as well as other complementary ones (triceps pull down, lateral raise and dumbbell curl).

In aerobic training, the volunteers walked outdoors on a 400-meter flat lane with an intensity between 60 and 80% of maximal heart rate that was obtained from a prediction equation accurate for this population (208 – 0.7 x age) [12]. Radial or carotid pulse was verified manually before, after 15 minutes and post-aerobic exercise. No volunteers were taking beta-blocker medications.

Warming and stretching exercises were given, lasting 5 minutes, at the beginning and at the end of each session, respectively. Nutritional interventions and psychological counseling were performed every fortnight, lasting 1 hour, each.

Interdisciplinary Intervention

The evaluations, analyzes and nutritional orientations were carried out from the results obtained through a 24-hour dietary recall and had the purpose of guiding and clarifying any doubts the participants might have regarding aspects of quality and nutritional quantity performed by a nutritionist. The topics covered in the meetings were: labeling, restrictive diets, salt and sugar in food, practical tips for healthy eating,

[11] BAECHLE, TR; GROVES, BR, **Weight training: steps to success eight training: steps to success eight training: steps to success**, [s.l.: s.n.], 1992.
[12] TANAKA, Hirofumi; MONAHAN, Kevin D.; SEALS, Douglas R., Age-predicted maximal heart rate revisited, **Journal of the American College of Cardiology**, v. 37, n. 1, p. 153–156, 2001; FRANCKOWIAK, Shawn C. *et al*, Maximal Heart Rate Prediction in Adults that Are Overweight or Obese, **Journal of Strength and Conditioning Research**, v. 25, n. 5, p. 1407–1412, 2011.

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hypertension, diabetes and in the last meeting a practical meeting in experimental cooking was held to put into practice the subjects addressed and strengthen the group relationship.

The purpose of the psychological counseling schedule was to assist the participants in managing the reduction of body mass, improve eating habits and other bodily conditions, such as pain, limitations and pleasures. The topics covered in the meetings were: motivation, body, strategies for a change, problems and frustrations, feminine universe, self-esteem and evaluation of the process at the end of the meetings. The interventions were performed by a psychologist.

Statistical analysis

The results are presented as mean ± standard deviation. We ran the Shapiro Wilk test to analyze the distribution of the data and subsequently two-way ANOVA with repeated measure as the results had pre and post analysis. Group and Time was used as independent factors. The Bonferroni post-test was also applied and the level of significance adopted was $p \leq 0.05$.

RESULTS

The groups were divided according to the order the participants had registered. The first 33 were assigned to the Inter + PT Group and the last 20 to the Inter Group.

During the program, 23 volunteers (Inter + PT = 13, Inter = 10) dropped out for personal reasons, 5 others from the Inter Group did not attend the follow up oGTT and 1 volunteer was not included in the sample because they started taking hypoglycemic medicine during the program. The mean age of the Inter Group was 58 ± 5.2 years and the Inter + PT 57.21 ± 4.84 years.

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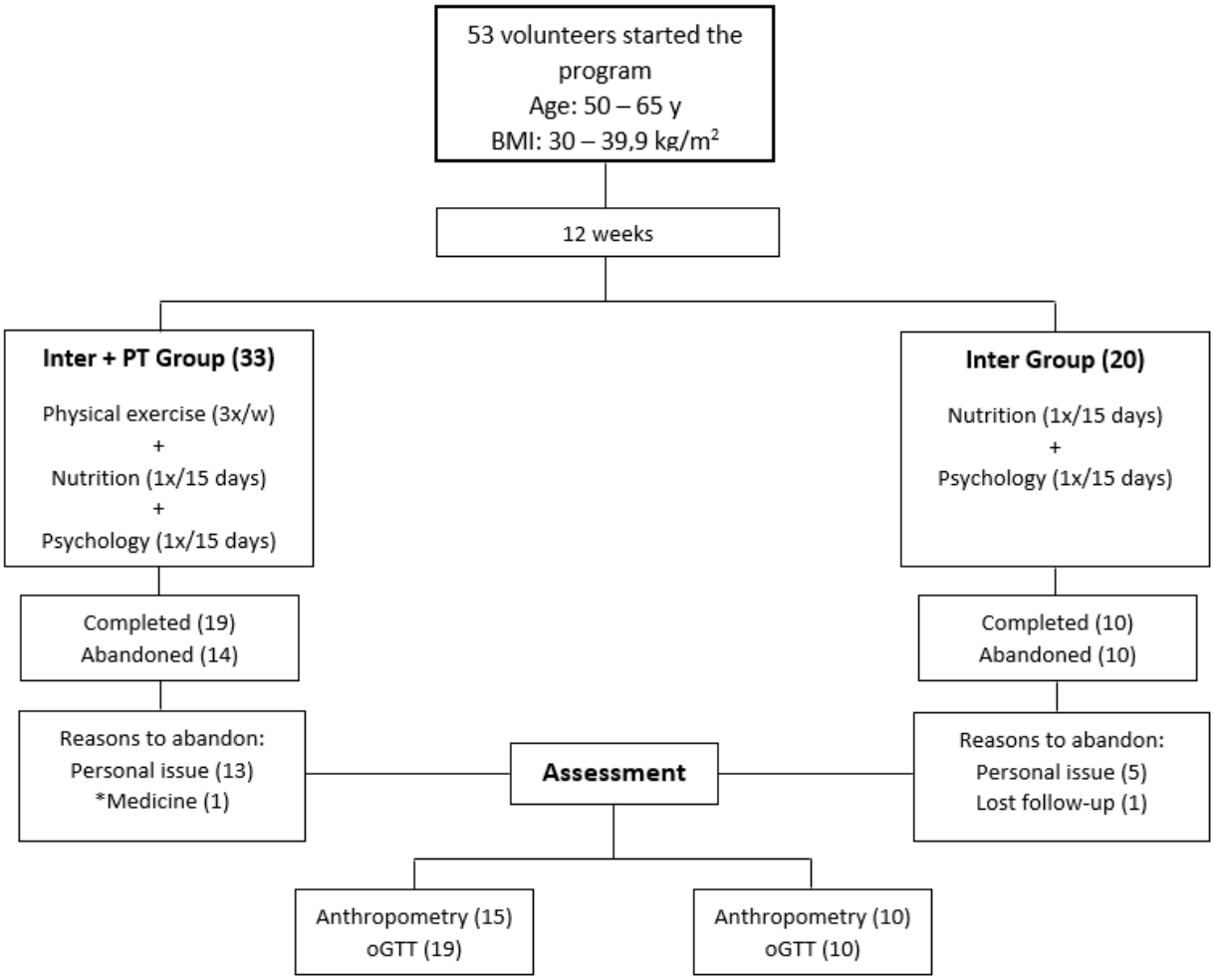
Figure 1: Study flowchart.



* Took hypoglycemic medication during intervention

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Table 1: Anthropometric data before and after interventions.

	Inter + PT (n=19)			Inter (n=10)			Inter+PT vs. Inter
	Baseline	**After therapy**	**p**	**Baseline**	**After therapy**	**p**	**p**
Body weight (kg)	86.34 ± 13.83	85.81 ± 13.84	0.26	93.45 ± 15.45	90.73 ± 13.17	0.01*	0.47
BMI (kg/m^2)	34.73 ± 3.57	34.32 ± 3.79	0.05*	37.39 ± 4.35	36.42 ± 4.13	0.01*	0.3
Neck circumferences (cm)	37.12 ± 2.85	37.28 ± 2.65	0.66	37.05 ± 2.43	37.28 ± 2.60	0.62	0.86
Waist cincumferences (cm)	103.61 ± 13.98	102.54 ± 11.99	0.37	109.95 ± 12,87	109.56 ± 9.66	0.87	0.29
Hip cincumferences (cm)	118.23 ± 11.15	116.16 ± 9.83	0.14	122.95 ± 15.32	121.64 ± 8.80	0.14	0.46
Waist-Hip Ratio (cm)	0.89 ± 0.09	0.90 ± 0.09	0.86	0.90 ± 0.07	0.90 ± 0.06	0.86	0.91

Data expressed as mean ± standard deviation

BMI = body mass index

*p ≤ 0.05 comparing before and after intervention.

Table 1 shows that there was no significant difference between groups in the parameters related to anthropometry, but a decrease in BMI was observed for both groups and body mass for the Inter Group when compared to the pre and post intervention moments.

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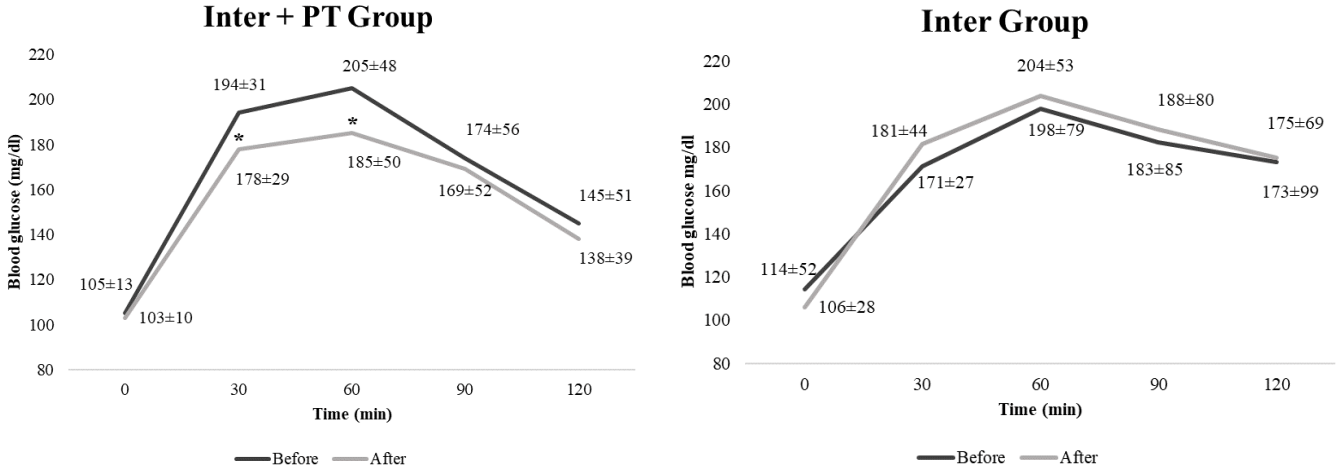
Table 2: 'p' values in oral glucose tolerance test (oGTT) and Area under the curve

oGTT	Inter + PT	Inter	Inter+PT vs Inter
0 min	0.48	0.14	0.52
30 min	0.01*	0.20	0.42
60 min	0.01*	0.53	0.80
90 min	0.44	0.49	0.58
120 min	0.29	0.81	0.18
Area under the curve	0.01*	0.37	0.69

This table shows the 'p' value in grupo*time; group*group
min = minutes

Figure 2: Glycemia at fast (0) and 30, 60, 90 and 120 minutes after the ingestion of 75g of anhydrous glucose.



Data presented in mean ± standard deviation.
* $p \leq 0.05$ comparing before and after intervention.

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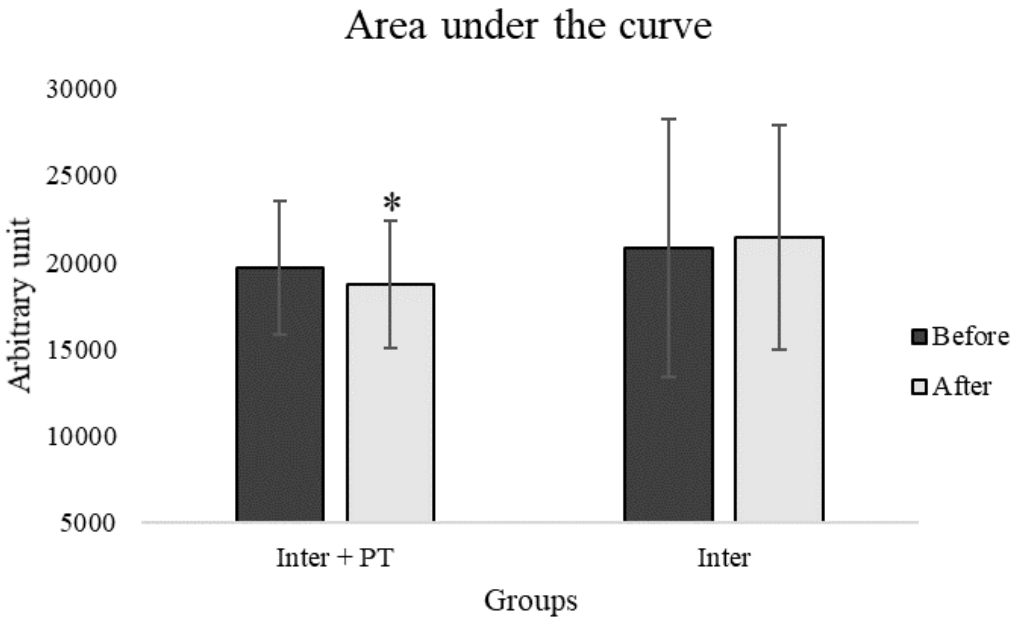
Figure 3: Results of the area under the curve (expressed in mg / dL / 120min) before and after Inter + PT and Inter therapy.



Data presented in mean ± standard deviation.
* $p \leq 0.05$ comparing before and after therapy.

The Inter + PT Group presented a significant reduction in blood glucose at 30 ($p = 0.011$) and 60 minutes ($p = 0.011$) when compared to the initial results. However, the Inter Group did not present significant changes at any of the times performed (Table 2, Figure 2).

In addition, a significant difference was found in the area below the glucose curve resulting from the interdisciplinary intervention associated with the combined training ($p = 0.012$), differently from that found in the Interdisciplinary intervention group ($p = 0.366$) (Table 2, Figure 3). There were neither significant differences in the comparison between the groups at oGTT times nor in the area under the glycemic curve.

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DISCUSSION

The interdisciplinary health program associated with combined physical training improved glucose tolerance regardless of changes in anthropometric parameters (except for BMI).

Although studies have shown a relationship between the decrease in values for fat mass and amount of visceral fat, with increased insulin sensitivity [13], we found a significant improvement in glucose tolerance even without a decrease in the majority of anthropometric parameters analyzed, especially waist circumference and waist/hip ratio, which are associated with the accumulation of visceral fat.

The results obtained from the Inter + PT Group corroborate current findings regarding the benefits of lifestyle change on improving the glycemic profile. Improvement in glucose tolerance and insulin resistance was observed after 6 months of interventions with physical exercise and nutritional monitoring in adults between 45 and 75 years [14]. After a one-year intervention, through exercise and diet, overweight and postmenopausal women reduced body mass significantly (-10.8%), and decreased body fat [15].

In this study, the physical training was the differential in the interventions, making it possible to state that it was essential in the improvement of glucose tolerance. In addition, other researches have demonstrated the benefits of combined physical training as a treatment and prevention of type 2 diabetes mellitus [16].

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In a study of 119 individuals with obesity and overweight, randomized into 3 groups (aerobic, resisted and combined training) for 8 months, the authors observed that combined training promoted a greater decrease in body fat percentage and waist circumference compared to the other groups, besides providing a significant decrease in body mass and an increase in lean mass [17]. Although the present study does not demonstrate changes in anthropometric values and body mass, it is possible to indicate that a longer program could modify these parameters.

Another work has reinforced the various benefits of combined training. Schwingshackl and colleagues, after a systematic review and meta-analysis with this type of training, concluded that aerobic and resistive training in the same session seem to prevent the decrease of lean mass as well as being more effective in the prevention and treatment of obesity [18].

On the other hand, despite the large capacity of combined training in promoting improvements in body composition and even in insulin resistance and glucose tolerance [19], most of the studies did not have obese women as volunteers after the menopause period.

Seen in these terms, Rossi and colleagues developed a clinical study using combined training in obese women after menopause for 16 weeks. The results showed an increase in lean mass and a decrease in the body fat of volunteers [20]. In addition, after

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and nutritional lifestyle intervention on glucose homeostasis in prediabetic individuals: a randomised controlled trial.

[17] WILLIS, L. H. *et al*, Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults, **Journal of Applied Physiology**, v. 113, n. 12, p. 1831–1837, 2012.

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combined training for 12 weeks, postmenopausal women decreased fasting glycemia, glycated hemoglobin, fasting insulin level and insulin resistance [21].

Another research conducted to investigate the 4- and 16-weeks effect of combined training on glycemic control and insulin action in overweight or obese type 2 diabetic women showed that fasting glucose, glucose tolerance and glycated hemoglobin decreased after 4 weeks. However, decrease in fasting glycemia and glycemia after 90 minutes in the oGTT occurred only after the 16th week [22].

Interventions performed specifically for the dietary alteration proposal may be able to reduce subcutaneous, visceral fat and cause improvements in metabolic profile such as: decrease in total cholesterol, fasting glucose and insulin, and decrease the resistance to this hormone in overweight/obese women after menopause [23]. Hence, we had expected a decrease in body mass and anthropometric variables in both groups, with more remarkable alterations in the group that practiced physical training, which did not happen.

Although the two groups participated in nutritional monitoring, the purpose of these interventions was not to prescribe diet, let alone with caloric restriction, but to work through workshops, information aimed at changing eating habits. Therefore, volunteers were encouraged to improve the quality of their food and not necessarily to reduce food consumption. This may explain the difference in body mass in both groups, since the Inter Group, when not practicing physical exercise, may have adopted a behavior resulting in a lower food intake or that the Inter + PT Group may have had an increase in sedentary

[21] MARTINS *et al*, High-intensity body weight training is comparable to combined training in changes in muscle mass, physical performance, inflammatory markers and metabolic health in postmenopausal women at high risk for type 2 diabetes mellitus: A randomized controlled cl.
[22] TOKMAKIDIS, Savvas P. *et al*, The effects of a combined strength and aerobic exercise program on glucose control and insulin action in women with type 2 diabetes, **European Journal of Applied Physiology**, v. 92, n. 4–5, p. 437–442, 2004.
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habits because they were practicing oriented physical exercise. Other studies have reported a similar situation [24].

In addition, intervention in the Inter Group was not sufficient to decrease waist circumference, which is related to the decrease in visceral adipose tissue and, consequently, an improvement in the glycemic profile. This data reinforces once again the role of physical training in the Inter + PT Group, although in the anthropometric profile there was only a change in BMI values, an increase in glucose tolerance was observed in the volunteers.

It is known that physical training improves insulin sensitivity by modulating proteins in the signaling pathway of this hormone, in addition to reducing the action of proinflammatory cytokines related to obesity, which interferes with the insulin signal.

In general, during an exercise session, in response to increased muscle contraction, increased glucose uptake occurs, without insulin mediation, due to increased stimulation of protein kinase-activated adenosine monophosphate (AMPK), which results in a chain of reactions that aims to increase GLUT4 translocation [25].

Chronic exercise, as in the present study, results in other physiological associations which are beneficial to glycemic regulation. Physical training is associated with an increase in the concentration of GLUT4 and other proteins in the insulin signaling pathway, as well as increased capillarization of skeletal muscle, which results in an increase in insulin sensitivity [26].

One of the pathways involved in regulating glucose uptake is the TBC1D4 protein. This protein is associated with an increase in post-exercise glucose uptake and is associated with increased Akt protein activity, thereafter increased GLUT4 translocation

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[24] SAKAMOTO, K.; HOLMAN, G. D., Emerging role for AS160/TBC1D4 and TBC1D1 in the regulation of GLUT4 traffic, **AJP: Endocrinology and Metabolism**, v. 295, n. 1, p. E29–E37, 2008; CARTEE, Gregory D., Roles of TBC1D1 and TBC1D4 in insulin- and exercise-stimulated glucose transport of skeletal muscle, **Diabetologia**, v. 58, n. 1, p. 19–30, 2015.

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[27]. In addition, physical training has the ability to decrease levels of PTP1B (tyrosine phosphatase 1B) that prevents the action of insulin, as well as its activity and association with the insulin receptor [28].

Thus, it is also worth mentioning that physical training is associated with a decrease in the inflammatory process resulting from obesity and, consequently, serum levels of TNF-α and other adipokines that impair glycemic regulation [29]. Despite not being measured in our study, it may have influenced the results obtained.

CONCLUSION

Therefore, we conclude that combined physical training is capable of potentiating the effects of an interdisciplinary program for obese postmenopausal women, significantly improving glucose tolerance.

Limitations

This study had the small number of participants in the Inter Group as a limitation, which may have interfered in not obtaining significant results in relation to oGTT. In addition, we did not follow the caloric intake of the volunteers or physical activity measures, which would have contributed to a discussion of the results obtained. We measured the heart rate only manually which prevented us from calculating the energy expenditure during physical exercise, in addition to decreasing the accuracy of the intensity of aerobic exercise.

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