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EFEITO DA DIETA LOWCARB SOBRE A COMPOSIÇÃO CORPORAL DE INDIVÍDUOS PRATICANTES DE MUSCULAÇÃO COM TREINAMENTO DE FORÇA

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Resumo. Introdução: A dieta low-carb vem sendo estudada, pois têm mostrado resultados significativos no benefício da redução de peso, por ser composta maioritariamente por proteínas e gorduras naturais com baixo potencial inflamatório, ajudando também a reduzir e a combater a retenção de líquidos. Esta dieta associada a treino de força poderia auxiliar no crescimento muscular bem como na redução da gordura corporal. Objetivo**:** Este estudo teve como objetivo analisar o efeito de uma dieta low-carb na composição corporal de praticantes de musculação submetidos ao treino de força. Metodologia:A amostra foi composta por 24 indivíduos do sexo masculino, não atletas, com idade entre 19 a 34 anos, com experiência em treinamento. Os participantes foram divididos em dois grupos, onde em um grupo foi submetido ao treino de força com dieta normocalórica, normoproteica, normolipídica e normoglicidica e o segundo grupo submetido ao treino de força com dieta lowcarbhipoglicídica, hiperproteica, hiperlipídica, durante o período de quatro semanas. Resultados**:** Ao comparar a composição corporal do grupo com a intervenção low-carb com relação ao grupo controle, não foram observadas diferenças significativas com relação aos dados de percentual da gordura corporal, percentual de massa magra, índice de massa corporal. Conclusão**:** Dadas as evidências prévias sobre a estratégia dietética low-carb, sugere-se a realização de mais estudos nesta área para o levantamento de novos resultados e conclusões.

Palavras-chave: Composição corporal, dieta baixa em carboidrato, dieta low-carb, fortalecimento por levantamento de peso.

Effect of carbohydrate diet on body compositionofindividualspracticingbodybuildingwithstrengthtraining

Summary. Introduction: The low-carb diet has been studied, as it has shown significant results in the benefit of weigh treduction, as it iscomposed most lyofproteins and natural fats with low inflammatory potential, also help ingto reduce and combat fluid retention. This diet combined withs trength training could help with muscle growth as well as reducing body fat. Objective: This study aimed to analyzeth effect of a low-carb diet on the body composition of body builders submitted to strength training. Methodology: The sample consisted of 24 male individuals, non-athletes, aged between 19 and 34 years, with training experience. Participants were divided into two groups, where in one group was submitted tostrength training with a normocaloric, normoproteic, normolipidicandnormoglycidic diet and the second group was submitted to strength training with a low carb, hypoglycemic, hyperproteic, hyperlipidic diet, during the period of four weeks. Results: When comparing the body composition of the group with the low-carbintervention in relation to the control group, no significant differences were observe dregarding the data of body fat percentage, lean mass percentage, body mass index. Conclusion: Given the previous evidence on the low-carbdietary strategy, further studies in this area are suggested toobta in new results and conclusions.

Keywords: Body composition, low-carb diet, low-carb diet, strengthbyweight lifting .

Efecto de una dieta baja en carbohidratos sobre la composición corporal de individuos que practican musculación con entrenamiento de fuerza

Resumen. Introducción: La dieta baja en carbohidratos ha sido estudiada, ya que ha mostrado resultados significativos en el beneficio de la reducción de peso, ya que está compuesta en su mayoría por proteínas y grasas naturales con bajo potencial inflamatorio, ayudando además a reducir y combatir la retención de líquidos. Esta dieta combinada con entrenamiento de fuerza podría ayudar con el crecimiento muscular y reducir la grasa corporal. Objetivo: Este estudio tuvo como objetivo analizar el efecto de una dieta baja en carbohidratos sobre la composición corporal de culturistas sometidos a entrenamiento de fuerza. Metodología: La muestra estuvo constituida por 24 individuos del sexo masculino, no deportistas, con edades comprendidas entre 19 y 34 años, con experiencia en entrenamiento. Los participantes fueron divididos en dos grupos, donde un grupo se sometió a un entrenamiento de fuerza con una dieta normocalórica, normoproteica, normolipídica y normoglicídica y el segundo grupo se sometió a un entrenamiento de fuerza con una dieta baja en carbohidratos, hipoglucemiante, hiperproteica, hiperlipídica, durante el período de cuatro semanas. Resultados: Al comparar la composición corporal del grupo con la intervención baja en carbohidratos en relación al grupo control, no se observaron diferencias significativas en cuanto a los datos de porcentaje de grasa corporal, porcentaje de masa magra, índice de masa corporal. Conclusión: Dada la evidencia previa sobre la estrategia dietética baja en carbohidratos, se sugieren más estudios en esta área para obtener nuevos resultados y conclusiones.

Palabras clave: composición corporal, dieta baja en carbohidratos, dieta baja en carbohidratos, fuerza por levantamiento de pesas.

Introduction.

The dietary basis of the individual plays a determining role in his or her physical condition, and every day new dietary proposals emerge that seek to modify the standard dietary basis in search of faster results (1,2).

In ancient times, being overweight was considered a condition of social status, since the person who presented a higher weight was considered more fortunate, thus showing his curves associated with his possessions (3). With the passage of time, society changed and in 1864, William Banting, in his quest for a lighter body, eliminated bread, potatoes, and sugar from his diet, eating basically meat, fish, and vegetables (4).

Over the years, diets have evolved and modernized according to new scientific findings regarding their efficacy. In 1972, later revised in 1992, Dr. Atkins' diet already recommended diets with a restricted amount of carbohydrates, with proteins and fats as the dietary basis (5). Then came Dr. Dukan's diet in 2000, where the basis was the same as that of Dr. Atkins, but the main difference was the priority given to monounsaturated and polyunsaturated fats, the famous good fats, and also that proteins should be lean and included physical activity in the weight loss program (6).

Currently, research has approached the efficacy of the ketogenic diet, which is given by the consumption of less than 10% of carbohydrates, and the low-carbohydrate diet, which in Portuguese would be a low-carbohydrate diet. The low-carbohydrate diet is characterized by a daily intake of 30 to 130g of carbohydrates (7). There is evidence that this dietary strategy favors the loss of body fat, by the mechanism of action of the insulin/glucagon ratio. It is known that carbohydrate is transformed into glucose and the same is absorbed by the liver, when many carbohydrate-rich foods are consumed, there is an increase in the release of insulin in the body, which in turn reduces the release of glucagon and is responsible for the burning of body fat. When foods rich in protein, quality fats, and fiber are consumed, there is a reduction in the amount of circulating insulin and, consequently, an increase in the release of glucagon. Thus, the individual can lose weight more quickly and effectively and, in parallel, obtains a decrease in the risks of developing cardiovascular diseases and other complications associated with overweight and obesity (8).

Nowadays, the routine with little time available has made the population increasingly sedentary and, consequently, more obese since the reduction of physical exercise associated with a poor-quality diet (based on processed and industrialized foods) leads to an increase in body weight, in addition to serious health problems. People show a certain urgency to obtain quick results and, considering that the low-carbohydrate diet is efficient in this sense, it has been one of the most applied and sought-after proposals nowadays when it comes to losing weight. On the other hand, strength training is more and more requested and takes precedence over aerobic training (2).

Strength training refers to an exercise or a sequence of exercises, which will help the individual's muscle building, aiming at the individual's anaerobic endurance. There is evidence that strength training associated with low-carbohydrate diets accelerates weight loss (6,9).

Methodology

The study consists of a non-randomized clinical trial (quasi-experimental).

This study was conducted from December 2020 to January 2021, with a total of four weeks of intervention. The study population was composed of students attending the Health and Movement gym, in the city of Balneário Arroio do Silva / SC, where the study was conducted. The sample was composed of 24 individuals. These correspond to 100% of the study population that fit the inclusion criteria, that is, non-athletes, in the age range of 19 to 34 years, male, with training experience, non-consumers of steroids. Participants were divided into two groups:

Group 1: Twelve individuals who underwent strength training with a normocaloric, normoprotein, normolipidemic, and normoglycemic diet.

Group 2: Twelve individuals who underwent strength training with a low-carbohydrate, hypoglycemic, hyperproteic, and hyperlipidemic diet, mainly rich in monounsaturated fat.

A non-probabilistic convenience sampling was performed in which the researcher uses subjective choice criteria. The participants were already practicing bodybuilding.

Inclusion criteria:

- Being a man

- No underlying chronic diseases

- Have experience in the practice of resistance training for a minimum of 90 days

- Not following a specific diet with nutritional control

- Sign the TCLE

Exclusion criteria:

- Being an athlete

- Being users of anabolic androgenic steroids

- Not agreeing with the study criteria and refusing to sign the TCLE

Measuring instruments and techniques

A digital scale (Omron HBF 514 model) used in the evaluation of body composition before and after the application of the dietary strategies in the intervention group and in the control group.

A tape measure stadiometer, without specific marking, was used in the evaluation of body composition before and after the application of the dietary strategies in the intervention group and in the control group.

The Cescorf adipometer was used in the evaluation of body composition before and after the application of the dietary strategies in the intervention group and in the control group. The adipometer was used to obtain the skinfold values of the participants in order to calculate the percentage of body fat and the percentage of lean mass of the participants.

The Cescorf tape measure was used in the evaluation of body composition before and after the application of the dietary strategies in the intervention and control groups.

The calculations and formulas to perform the physical assessment of individuals and determine body composition used the equation of Jackson and Pollock (10) published in 1978 [1.112- 0.00043499 x (Σ 7 folds) + 0.00000055 x (Σ 7 folds) 2 - 0.00028826 x (age)]. This equation was developed to estimate the body fat content of men (10).

Basal metabolic rate (BMR) and total energy expenditure (TEE) were determined using the Harris and Benedict formula (11), which for the male sex is TEE = 662 - (9.53 x I) + [NAF x (15.91 x P + 539.6 x A)], where P is weight, A is height, and I is age. The physical activity factor (PAF) ranks: sedentary 1.0, light 1.11, moderate 1.25, intense 1.48. Both for the age group 19 years and older (11).

The participants were divided into two groups. After the separation of the groups, an analysis of the body composition of the individuals was performed: percentage of body fat and muscle mass.

The intensity of the strength training was adjusted to 80% using the one repetition maximum (1RM) test for the main strength training exercises. The training was composed in the frequency of five times per week, where chest, shoulder, triceps, back, biceps, and lower limbs were worked. Multiple series system of three series with 8 to 12 repetitions for the exercises with 4 exercises for the chest, back, and lower limbs groups and 3 exercises for shoulder, triceps, and biceps, with interval of 45 seconds to 1 minute and 30 seconds, with the division of the weekly training in format A (chest, shoulders, and triceps), B (back and biceps), and C (lower limbs). All workouts were accompanied by a professional (12-14).

The caloric restriction to be followed during the research through the *low-carbohydrate* diet with 100 grams of carbohydrates per day is through the consumption of less than 200 grams of carbohydrates per day. The other macronutrients being in the range of 35 to 40 percent lipids and 35 to 40 percent protein calculated individually. Complex carbohydrates are used to replenish muscle glycogen stores and are consumed in the first meal after training and in 3 more meals.

Participants in the control group received a normocaloric (individually calculated GET value), normoglycemic (50% carbohydrate), normoproteic (30% protein), and normolipidic (20% lipid) diet also prescribed by the nutritionist (15).

The analysis was performed with the GraphpadPrism program, version 6.01, in which the *one-way Anova* analysis was chosen for paired dependent and independent samples, intergroup and intragroup with mean and standard deviation, using p-value <0.05 (level of significance considered).

Results

This study had as population sample 24 students, being 12 students from group 1, and 12 students from group 2, from a bodybuilding gym. The participants were male, with an age range of 19 to 34 years, who had experience in training and were not steroid users.

The data in the tables are intended to present the mean, standard deviation, maximum and minimum values of variables such as age, height, weight before and after, and Body Mass Index (BMI) before and after sampling, as presented in Tables 1 and 2.

Table 1. General data of the control group

	Age (years) Group 1	***Height (m) Group 1***	***Weight (kg) Before Group 1***	***BMI (Kg/m²) Before Group 1***	***Weight (kg) After Group 1***	***BMI (Kg/m²) After Group 1***
Participants	12	12	12	12	12	12
Mean	27,5	1,76	85,62	27,48	85,75	27,52
Standard deviation	5,78	0,07	12,78	3,22	12,27	2,97
Minimum	19	1,68	65,3	23,14	66,7	23,63
Maximum	36	1,92	104	34,35	103	34,02

Grando (2021)

According to Table 1, the participants had a mean age of 27.5 years and a mean BMI value of 27.52kg/m^2 after the intervention. Being that the classification for BMI is less than 18.5 - Underweight, between 18.5 and 24.9 - normal weight and between 25 and 29.9 - Overweight (above the desired weight), Equal or above 30 - Obesity (16).

***Table 2*:** general data of the intervention group

	Age (years) Group 2	***Height (m) Group 2***	***Weight (kg) Before Group 2***	***BMI (Kg/m²) Before Group 2***	***Weight (kg) Then Group 2***	***BMI (Kg/m²) Then Group 2***
Participants	12	12	12	12	12	12
Mean	27,7	1,76	85,75	27,96	84,25	27,44
Standard deviation	4,33	0,09	7,96	4,05	7,22	3,61
Minimum	19	1,68	75	21,83	73	21,83
Maximum	34	1,95	102	35,29	98	33,91

According to Table 2, the participants had a mean age of 27 years and a mean BMI value of 27.44kg/m^2 after the intervention. Being that the classification for BMI is less than 18.5 - Underweight, between 18.5 and 24.9 - normal weight and between 25 and 29.9 - Overweight (above the desired weight), Equal or above 30 - Obesity (16).

Figure 1 shows the graphical analysis of the BMI of the research participants. No significant differences were observed when comparing the groups before and after, nor between the groups after the four weeks of intervention. There were no significant differences between the same group and between groups.

Figure 1. Groups 1 and 2: Between control and intervention groups

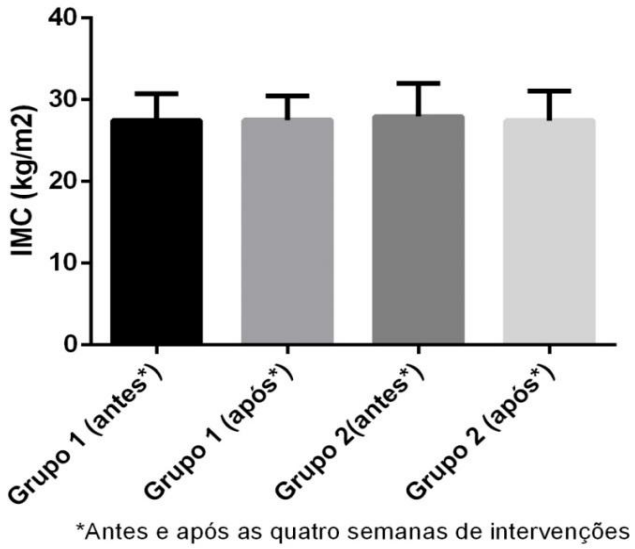


Figure 2 presents the graphical analysis of the body fat percentage of the research participants. No significant differences were observed when comparing the groups before and after, nor between the groups after the four weeks of intervention. Both groups remained with a body fat percentage similar to the initial assessment.

Figure 2**.** Groups 1 and 2: Between control and intervention groups

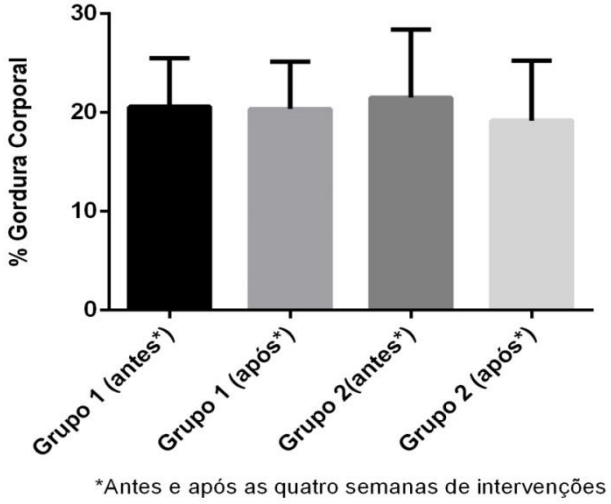
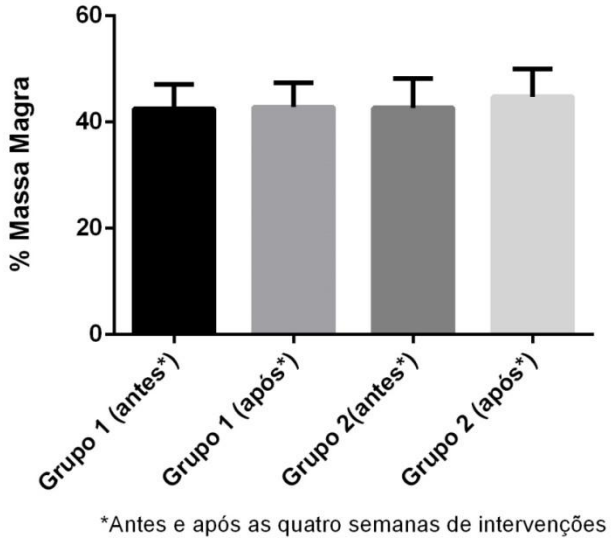


Figure 3 shows the evaluation of the percentage of lean mass of the overall sample of research participants. No significant differences were observed when comparing the groups before and after, nor between the groups after the four weeks of intervention. Both groups remained with a lean mass percentage similar to the initial assessment.

Figure 3. Groups 1 and 2: Between control and intervention groups



Discussion and conclusions

The BMI data before and after the intervention showed overweight in the participants as shown in Table 5.1. However, when measuring BMI and verifying that it is above normal, it is advisable to perform a body composition assessment. The objective is to verify if the excess weight is related to their amount of lean mass (muscle, bone, and residual weight) or adipose (fat) (15).

BMI should always be associated with the evaluation of the percentage of body fat and the percentage of lean mass in order to have a correct and more reliable physical evaluation (16,17). The present study aimed to evaluate BMI before and after the

application of strength training and low-carbohydrate diet to complement the physical assessment, but no significant differences were observed in the comparison between groups. The study by Creighton et al. (17) observed in competitive runners that the metabolic profile obtained significant improvements with no change in the BMI of the participants.

Penteado et al. (16), who evaluated the BMI of 13 athletes of an indoor soccer team in 2009, reported that 61.4% of the participants were overweight and obese. However, the percentage of body fat was estimated between normal and below the recommended range, confirming that the assessment of nutritional status through BMI is not the most appropriate parameter since it is based on the relationship between weight and height. However, it is not an accurate measure of body fat content and, in this case, should be associated with another indicator of body composition (18).

Low-carbohydrate diets have recently become very popular due to their numerous health benefits. Several studies have been conducted on the impact of low-carbohydrate diets on improving exercise performance in athletes, reducing fat content, and decreasing the risk of dyslipidemia or insulin resistance in overweight and obese individuals (18-20).

Starting training with a low carbohydrate reserve promotes improvements that favor lipid metabolism as well as limiting performance for more intense workouts, just as a diet rich in fat can favor greater fat oxidation, but energy restriction is usually linked to the pursuit of aesthetic purposes and in strength sports athletes (9,12). The present study evaluated the percentage of body fat before and after group 1, which was the control group with fitness training associated with a standard diet, and before and after group 2, the intervention group, which performed strength training and received the low-carbohydrate diet, finding no significant difference in the comparison between groups. Michalczyk (21) conducted a study with competitive basketball players, where he used the low-carbohydrate diet for four weeks and obtained a significant reduction in the percentage of body fat contradicting the results found but also obtained no significant differences in the percentage of lean mass, which corroborates the results of this study, and was evaluated before and after in both group 1 and group 2.

The maintenance of lean mass is extremely important and it should be remembered that this component is directly influenced by the level of muscle glycogen, which is almost twice as high in competitive athletes compared to untrained individuals, so biochemical analysis is necessary in future analyses (22).

Rothschild and Earnest (23) observed in their study an improvement in mitochondrial enzyme activity, mitochondrial content, and fat oxidation rates; however, they did not observe any significant difference in physical changes on acute application of the low-carbohydrate diet, just as this study found no significant difference in this study, highlighting the importance of biochemical analysis in the future.

According to the research of Guimarães et al. (24), where tests and application of the low-carbohydrate diet were performed in 60 participants who practiced weight training to analyze weight reduction and lean mass gain, the result was an average weight reduction of around 2.5 kg and a reduction in BMI close to 0,9 kg/m^2, in addition to an increase in lean mass and a reduction in fat mass, highlighting the greater reduction in average body weight in men (-3.8 kg) relative to women (2.4 kg), which was not observed in the present investigation, as it did not include a sample of women. It is believed that,

if the cited study had only analyzed the before and after, it would have the same results; however, a deeper analysis is necessary for this statement.

It can be observed in the same way in the qualitative study conducted by Fiuza (25), where he makes a relationship between men and women, applying the low-carbohydrate diet during a period of one month, in 15 practitioners of resistance training. The age range of the participants was from 20 to 52 years, with a predominance of 20 to 28 years, and the female audience was 67% and the male 33%. The research revealed that, in both groups, there was loss of fat mass, but this significant reduction is only observed when comparing the groups between genders; however, it does not show the results within the same gender as in this study.

One of the factors that reduce the effectiveness of adherence to dietary reeducation diets is the difficulty in losing weight, sometimes related to sedentary lifestyle, poor eating habits, noncompliance with diet, and physical activities or individual comorbidities that cause patients to drop out before achieving significant results. In this sense, the choice of the low-carbohydrate diet promotes faster weight adjustment, thus favoring greater patient adherence to the therapeutic process (14).

In a study conducted by Francisco (26) for a year and a half, it was divided into 3 phases, the first and second being the phase of application of the low-carbohydrate diet that resulted in the desired weight loss, and the third phase, after one year of the first and second phases, the participants continued to maintain the weight achieved and the eating habits developed during the intervention. Of this participant population of 663 individuals, only 70 agreed to undergo the nutritional evaluation after one year, where it is observed that the BMI of the participants at the beginning of the research, being 60% of the individuals pre-obese and 27.8% with grade I obesity, and the rest presented grade II and III obesity. At the beginning of the maintenance phase, the participants were classified as 45.1% eutrophic, 44.7% pre-obese, and 8.6% grade I obese; and after one year, 35.8% of the 21 participants were eutrophic, 47.2% pre-obese, and 15% grade I obese. This study showed that the low-carbohydrate diet was effective in the application period. However, it needs an adequate period of application to observe a response to treatment. It is believed that this has been the most striking factor in the results presented in the current research, which was based on a short period of application made it possible to obtain significant results, suggesting that a longer period of application of the diet would have a promising result.

A nutritional research was conducted on the application of the low-carbohydrate diet in runners based on the energy expenditure of the group and sports performance before and after the test period. Having street running as an aerobic sport, Leite (27) understood in his research that the low-carbohydrate diet did not bring benefits to the participants of the project, where he did not find significant results with the diet. However, it is believed that associated with strength training the results are more promising, even not having found significant difference in this study.

Hashimoto et al. (28), during the first meta-analysis on the effect of the low-carbohydrate diet on fat percentage and body weight in patients seeking to lose weight, regardless of age and gender, observed that there was a greater loss of fat mass with the application of the low-carbohydrate diet compared to the other conventional control diets due to the higher protein intake. This study was one of those used in the search for material for the development of this work; however, the expected result was not obtained as shown in this meta-analysis.

According to Perroni et al. (29), although low-carbohydrate diets may provide metabolic benefits, when less than 50 g of carbohydrate/day is offered, it may result in ergolytic effects, i.e., it may end up compromising the individual's physical capacity or performance in activities such as strength training itself.

Lacerda (30) conducted a qualitative study with Crossfit practitioners to evaluate physical results. A reduction in hip and waist circumferences, loss of fat percentage and body weight was observed; however, there were no significant changes in the percentage of lean mass, and the participants continued with the nutritional diagnosis of overweight. The women's group presented a loss of about 4kg in relation to the initial weight and 4cm of loss in waist measurements, while the men showed a significant difference of almost 10kg in relation to the initial weight. There was also a reduction in BMI in both genders evaluated. This study, despite not considering a dietary intervention, was considered relevant as CrossFit is also classified as strength training. However, this work by Lacerda does not corroborate with the findings of this study in which no significant difference in body fat and body weight loss was observed, even using the same four-week training and diet application period.

According to Astrup and Hjorth (31), the efficacy of the low-carbohydrate diet depends directly on the metabolic system of each individual. Research conducted among individuals who were subjected to three types of diets, including the low-carbohydrate diet, indicated that the low glycemic index presented by the low-carbohydrate diet provides an improvement in the metabolism of individuals, such as the reduction of the lipid, glycemic, and hepatic profile; this being one of the key parts for the weight loss result. The study also revealed that most of the prediabetic individuals reduced their weight with a diet oriented to a lower quantity and higher quality of carbohydrates ingested, with a higher consumption of whole grains and fiber. This study reinforces the importance of biochemical analysis and new findings should be sought in the current research, and that physical assessment alone was not effective in obtaining significant results.

A very controversial study by Kabisch et al. (32), in 140 individuals with non-alcoholic fatty liver disease, indicated that there were no changes in hepatic fat with the application of the low-carbohydrate diet, but there were significant changes in the reduction of obesity indexes according to BMI and triglyceride parameters. Diets with fat reduction in the case of patients with hepatic fat showed more significant changes than the application of diets with lower carbohydrate intake (32). Other studies found in the literature show the efficacy of the low-carbohydrate diet in the reduction of non-alcoholic hepatic steatosis, reflected in the percentage of body fat (33), being what this study sought in its analysis.

Araujo et al. (34) conducted a test application of a high-protein, low-carbohydrate diet together with strength training in a group of 25 overweight older women. The diet consisted of protein (1.8g/kg/day x 1.0g/kg/day) and carbohydrate (2.0g/kg/day x 3.0g/kg/day) and similar amounts of lipids and fiber for a period of eight weeks. Compared to the traditional control diet (normo-glycemic, lipid, and protein), the hyperprotein diet with reduced carbohydrate intake showed no significant differences in fat mass loss and reduction in measurements. Similar to the results of this study, no significant differences were observed in the analysis of body weight and fat mass percentage.

Research was conducted with eight cyclists, comparing the efficacy of a Western diet with the low-carbohydrate diet. This research was applied for a period of four weeks for each diet, and the results showed that there was reduction of BMI, improvement of lipid and lipoprotein profile, and biochemical improvement of the participants (35), which differs from the BMI findings, but the biochemical analysis was not performed, and it is believed that, if it had been performed, the results would be significant as shown in other studies.

This study showed no significant changes in body fat percentage, lean mass percentage, body mass index, both in group 1 and group 2, which performed the application of the low-carbohydrate diet together with strength training. Regarding the BMI of the participants, there was a mean reduction of approximately 1.38 kg/m2 in relation to the maximum obtained before the intervention and after the investigation, which is not considered a significant reduction for the investigation. Regarding the weight of the participants, the mean reduction was 2 kg relative to the initial minimum weight in both phases and 4 kg relative to the maximum weight between them within standard deviation. Even without significant changes, it can be noted that, in numbers, the changes occurred were more visible in group 2, so the continuation of extension research on the subject of the effectiveness of low-carbohydrate diets with the help of strength training is necessary to have more material and knowledge on the subject.

After four weeks of intervention with a low-carbohydrate diet in individuals practicing strength training, no significant differences were observed in terms of BMI, fat percentage, or lean mass of the participants at the end of the application.

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