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Different methods of nutritional interventions for weight loss: randomized controlled clinical trial

Diferentes métodos de intervenções nutricionais para perda de peso: ensaio clínico randomizado controlado

Diferentes métodos de intervenciones nutricionales para la pérdida de peso: ensayo clínico controlado randomizado

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ABSTRACT

Objective: The present study aimed to evaluate and compare the effects of intermittent fasting, low carb and hypocaloric diets on weight control, lean and lipid mass and lipid and glycemic profiles in obese volunteers. **Methods:** This is a randomized clinical trial in which the sample consisted of a 30 individuals group, of both sexes, aged between 18 and 40 years with Body Mass Index (BMI) > 25 kg/m² and with similar organic conditions in which they were divided into 3 groups and submitted to the above mentioned diets for 30 days. **Results:** The results revealed by anthropometry, bioimpedance and laboratory tests show that when the values in the groups are compared separately, we have significant variables. **Conclusion:** Thus, the hypocaloric diet showed better results, mainly in weight and BMI (body mass index), which helps to control possible patient comorbidities. And in relation to laboratory tests, the Low carb diet and intermittent fasting had good results with reduced levels of blood glucose, total cholesterol, triglycerides, High-density lipoprotein (HDL), Low-density lipoprotein (LDL) and Very low-density lipoprotein (VLDL).

Keywords: Obesity, Low carb, Intermittent fasting, Hypocaloric diet.

RESUMO

Objetivo: O presente estudo teve como objetivo avaliar e comparar os efeitos do jejum intermitente, das dietas Low Carb e hipocalórica sobre o controle de peso, massa magra e lipídica e perfis lipídico e glicêmico em voluntários obesos. **Métodos:** Trata-se de um ensaio clínico randomizado em que a amostra constou de um grupo de 30 indivíduos, de ambos os sexos, com idade entre 18 a 40 anos com Índice de massa corporal (IMC) >25 kg/m² e com condições orgânicas semelhantes na qual foram divididos em 3 grupos e submetidos às dietas citadas à cima por 30 dias. **Resultados:** Os resultados revelados pela antropometria, bioimpedância e exames laboratoriais mostram que quando comparados os valores nos grupos separadamente temos variáveis significativas. **Conclusão:** Sendo assim, a dieta hipocalórica apresentou melhores resultados, principalmente no peso e IMC, o que auxilia no controle dos pacientes. E em relação aos exames laboratoriais a dieta Low carb e jejum intermitente tiveram bons resultados com redução dos níveis de glicemia, colesterol total, triglicerídeos, lipoproteína de alta densidade, lipoproteína de baixa densidade e lipoproteína de muito baixa densidade.

Palavras-chave: Obesidade, Low carb, Jejum intermitente, Dieta hipocalórica.

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RESUMEN

Objetivo: El presente estudio tuvo como objetivo evaluar y comparar los efectos del ayuno intermitente, las dietas bajas en carbohidratos (Low carb) e hipocalóricas sobre el control de peso, la masa magra y lipídica y los perfiles lipídico y glucémico en voluntarios obesos. **Métodos:** Se trata de un ensayo clínico randomizado en el que la muestra estuvo constituida por un grupo de 30 individuos, de ambos sexos, con edades comprendidas entre 18 y 40 años con Índice de Masa Corporal (IMC) >25 kg/m² y con condiciones orgánicas similares en los que se dividieron en 3 grupos y sometido a las dietas antes mencionadas durante 30 días. **Resultados:** Los resultados revelados por antropometría, bioimpedancia y pruebas de laboratorio muestran que cuando se comparan los valores en los grupos por separado, tenemos variables significativas. **Conclusiones:** Por lo tanto, la dieta hipocalórica mostró mejores resultados, especialmente en peso e IMC, lo que ayuda en el control de los pacientes. Y en relación a las pruebas de laboratorio, la dieta baja en carbohidratos (Low carb) y el ayuno intermitente tuvieron buenos resultados con niveles reducidos de glucosa en sangre, colesterol total, triglicéridos, lipoproteína de alta densidad, lipoproteína de baja densidad y lipoproteína de muy baja densidad.
Palabras clave: Obesidad, Low carb, Ayuno intermitente, Dieta hipocalórica.

INTRODUCTION

The global obesity epidemic continues its relentless advance, currently affecting more than 2 billion people and is considered a growing public health problem worldwide. In general, obesity is defined as the excessive accumulation or abnormal distribution of body fat, affecting health, being classified by the body mass index (BMI) (CABALLERO B, et al., 2019; HANKEY C, 2018). Obesity is related to the evolution of other diseases such as type 2 diabetes mellitus, hepatic steatosis, cardiovascular disease, cerebral vascular accident, dyslipidemia, hypertension, gallbladder problems, osteoarthritis, sleep apnea and other respiratory problems, and certain types of cancer (endometrial, breast, ovary, prostate, liver, gallbladder, kidney and colon). The main effects of obesity on cardiovascular health are mediated by the risk of metabolic syndrome (insulin resistance, dyslipidemia and hypertension) (MAYORAL LP, et al., 2020; KACHUR S, et al., 2017).

The patients present better conditions for behavioral change and weight loss when they are still overweight, that as obesity represents a major public health problem and its prevalence in adults was 61,7% in 2019.Thus, the interventions should preferably be performed at this stage of patients before comorbidities set in and when behavioral changes are better accepted (JESUS J, et al., 2022). Obesity should and can be treated primarily through diet and behavioral modification. In long term, the method, speed of weight loss, physiological adjustment and the ability to maintain behavioral changes in diet and physical activity will determine the success of any weight loss program. Dietary treatment of obesity is difficult, usually tends to restrict the calories consumed and forgets the biopsychological factors and lifestyle of the patients. However, there is not a specific single diet for these diseases, but the diet must be individualized, based on therapeutic goals adapted to dietary recommendations for the patient's lifestyle (DURRER SD, et al., 2019; RIOBÓ S, 2018).

Currently, intermittent fasting, low carb and caloric restriction are the most researched diets regarding their action and efficiency in the treatment of obesity. Intermittent fasting is based on acute food restriction, which can vary from 12 to 24 hours with different weekly frequencies. The low carb diet is based on carbohydrate restriction, the percentage of the nutrient in the diet can vary between 44% - 11% of the total caloric value. Finally, caloric restriction, as the name implies, is characterized by calorie restriction consumed, the recommendation is that calories be reduced from 500 to 1000kcal/d in obese patients (FREIRE R, 2020).

In this sense, the present study aimed to evaluate and compare the effects of intermittent fasting, Low Carb and hypocaloric diets on weight control, lean and fat mass, lipid and glycemic profiles of overweight patients.

METHODS

This is a randomized and controlled clinical trial where the control is a hypocaloric diet. The individuals in the sample were recruited through an advertisement made at a university The sample consisted of a 30 individuals group, of both sexes, aged between 18 and 40 years with BMI>25 kg/m² and with similar organic conditions so that it was not an interfere. Patients signed the informed consent term before the start of interventions. The subjects were divided in three groups, randomly allocated: a control group (n=12) that underwent a hypocaloric diet with 1800 calories daily, an experimental group (n=9) that underwent intermittent fasting and the last group that underwent a low carb diet (n=9). Intermittent fasting consisted of a procedure in which volunteers were instructed by the nutrition team to follow a standardized diet of 1800 kcal over 30 days with periods of fasting followed by adequate breakfast.

They followed a 16-hour fasting with alternating days, one with fasting and the other without. The group that performed the low carb diet was instructed in these 30 days to follow a diet also of 1800 kcal, but in this case with restriction of the percentage of carbohydrates of 40% of the total caloric value. While the control group followed a 1800 kcal balanced and hypocaloric diet during the 30 days (with 50% CHO; 25 lipids; 25% protein). The diets were prescribed by a nutritionist specializing in clinical nutrition.

The volunteers were submitted to the diet for a period of thirty days and all groups had standardized diets of 1800kcal with nutritional monitoring during thirty days by digital means. In addition, fasting individuals blood samples were collected from all research participants to determine lipid levels (total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein LDL, VLDL, triglycerides) and fasting blood glucose. The evaluation of lipid and glycemic levels was performed by means of the determination of commercial kits of the Análise® brand. The LDL cholesterol concentration was calculated using the Friedewald formula. The exclusion criterion was patients who were unable to follow the proposed diet during the 30 days.

Overweight patients present better conditions for behavioral change and weight and weight loss, thus being chosen for this study. Anthropometric assessment was also performed in all groups of research participants before the start of the diet and after the thirty days of diet.

Body mass was assessed using a mechanical anthropometric scale (WelmyR brand) with a weighing capacity of up to 150 kg and a sensitivity of 0.1 kg, and height was measured using a stadiometer attached to the scale. Through these two measurements, it was possible to calculate the body mass index (BMI), using the BMI values recommended by the WHO as a classification criterion (CERCATO C, 2016).

Subjects underwent body composition assessment by Biodynamics® model 450 bioelectrical impedance analysis (BIA). Volunteer assessments were conducted using a connection between the analyzer and the patient's wrist and ankle. Resistance and reactance, the two components of impedance, are measured directly from the body. The body composition parameters analyzed were total corporal water [TW], body cell mass [BCM], lean mass appliance [LMA], fat mass appliance [FMA].

To compare the variables between the three groups, measured at the beginning and at the end, the non-parametric Kruskal Wallis test was used, at the nominal level of 5% of significance. The Wilcoxon sign test for 2 paired samples was used, at the nominal level of 5% of significance, to compare the variables within each of the three groups, measured at the beginning and at the end, for each variable.

The graphical representation was made using the Box Plot, as the median was the most adequate measure of position, due to the data distribution being asymmetric. Statistical analysis was performed using the R software (R DEVELOPMENT, 2020). Ethics committee approval: 3,605,274/2,746,395.

This study was approved by the Ethics Committee of the Universidade José do Rosário Vellano (UNIFENAS), under opinion number 3.605.274 (CAAE 19233019.7.0000.5143) and 2.746.395 (CAAE 89276418.4.0000.5143), as well as, was registered in the Brazilian Registry of Clinical Trials (ReBEC) under code U1111-1286-6812 (https://ensaiosclinicos.gov.br/rg/RBR-6vbzs7m).

RESULTS

Table 1 describes the results of anthropometry and body composition variables evaluated by bioimpedance. Weight, BMI, TBW, BCM, FFM, FMA and other demonstrated variables did not show statistical differences between the groups, as well as at the beginning and end of the study.

Table 1 - Median values of each variable measured at the beginning and at the end, among the three groups.

Variables	Moments	Median Groups			p value
		Kcal restriction (n:12)	Low (n:9)	Fasting (n:9)	
Mass	Initial	74.35	72.50	73.90	0.355
	Final	72.45	71.90	73.00	0.317
BMI	Initial	26.10	25.90	27.90	0.978
	Final	25.20	25.80	27.50	0.795
LMA	Initial	48.10	42.00	46.40	0.182
	Final	46.25	45.90	45.30	0.822
FMA	Initial	25.40	30.10	27.90	0.363
	Final	23.10	27.90	29.15	0.198
BCM	Initial	22.90	21.00	23.40	0.198
	Final	23.30	21.80	22.20	0.530
EM	Initial	23.30	21.70	28.20	0.095
	Final	22.45	22.20	23.70	0.433
CFM	Initial	64.22	61.49	62.65	0.437
	Final	65.04	61.42	61.07	0.287
CLM	Initial	37.78	38.50	37.34	0.363
	Final	34.22	38.58	38.92	0.130
TWA	Initial	74.35	72.30	73.90	0.358
	Final	72.70	76.25	73.00	0.609
BMR	Initial	1449.50	1310.00	1448.00	0.176
	Final	1443.00	1373.00	1413.00	0.604
IW	Initial	17.45	17.10	17.90	0.251
	Final	17.75	16.90	17.20	0.774
EW	Initial	14.85	13.50	17.70	0.110
	Final	14.45	14.30	15.40	0.362
TW (%)	Initial	79.95	72.00	70.20	0.229
	Final	71.35	71.00	70.80	0.552

Subtitle: BMI - Body mass index, LMA - Lean mass appliance, EM - extracellular mass, FMA - Fat mass appliance, BCM - Body cell mass, CFM - Calculated fat mass, CLM - Calculated lean mass, TWA - Total weight appliance, BMR - Basal metabolic rate, IW – Intracellular water, EW – Extracellular water, TW – Total corporal water. Significance p<0,05 Kruskal Wallis test.
Source: Silvério AP, et al., 2023.

Table 2 shows the data from laboratory tests of the three groups as well as the statistical significance. When analyzing the initial glucose and LDL between the groups, the value was different between them.

Table 2 - Analysis of laboratory variables (medians) measured at the beginning and at the end, among the three groups.

Variables	Moments	Median Groups			p value
		Kcal restriction (n:12)	Low(n:9)	Fasting(n:9)	
Glucose	Initial	82.50[A]	77.00[B]	81.00	0.049*
	Final	78.50	75.50	79.00	0.124
TC	Initial	188.50	238.00	202.00	0.051
	Final	170.00	202.00	185.00	0.218
Tri	Initial	120.50	102.50	178.00	0.432
	Final	100.00	69.00	115.00	0.306
HDL	Initial	34.00	34.00	35.00	0.654
	Final	43.50	46.50	37.00	0.348
LDL	Initial	126.40[A]	164.40[B]	146.00[B]	0.043*
	Final	105.00	140.80	121.00	0.156
VLDL	Initial	27.00	20.40	35.60	0.474
	Final	20.40	13.80	23.00	0.199

Subtitle: TC – Total cholesterol, Tri – Triglycerid, HDL – High-density lipoproteins, LDL – Low-density lipoproteins, VLDL – Very Low-density lipoproteins. * significance p<0,05 Kruskal Wallis test; A versus B p<0,05 Mann Whitney test.
Source: Silvério AP, et al., 2023.

We can see in **Table 3** that when the values in the groups are compared separately, we have more significant variables. In the hypocaloric diet group, we had significant values in weight, BMI, extracellular mass, total weight calculated by the device and extracellular water when comparing the final and initial ones. In the Low Carb group, there were no significant variations. In addition, in the last group, the intermittent fasting group, we observed significance in the lean mass calculated by the device, body cell mass, calculated lean mass, basal metabolic rate, intracellular water and total body water.

Table 3 - P values from the comparative analysis of median values obtained at baseline versus final in each group.

Variables	p value - Groups		
	Kcal Restriction (n:12)	*Low* (n:9)	*Fasting* (n:9)
MASS	0,004**	0,570	0,342
BMI	0,003**	0,766	0,233
LMA	0,082	0,910	0,009**
FMA	0,068	1,000	0,182
BCM	0,722	0,677	0,021**
EM	0,005**	0,677	0,528
CLM	0,347	0,484	0,021**
CFM	0,374	0,779	0,344
TWA	0,004**	0,484	0,110
BMR	0,345	0,260	0,008**
IW	0,666	0,401	0,025**
EW	0,005**	0,767	0,600
TW (%)	0,366	0,343	0,008**

Subtitle: BMI - Body mass index, LMA - Lean mass appliance, FMA - Fat mass appliance, BCM - Body cell mass, EM - extracellular mass, CLM - Calculated lean mass, CFM - Calculated fat mass, TWA - Total weight appliance, BMR - Basal metabolic rate, IW - Intracellular water, EW – Extracellular water, TW – Total corporal water.
Source: Silvério AP, et al., 2023.

This **table 4** shows that it was mostly significant when comparing the initial and final values of the laboratory tests. In the hypocaloric diet group, the significant results were from total cholesterol, triglycerides, HDL and LDL. In the Low Carb group, significance was observed in total cholesterol, triglycerides, HDL, LDL and VLDL. In intermittent fasting, good results were obtained in total cholesterol, triglycerides, HDL, LDL and VLDL.

Table 4 - P values from the comparative analysis of median values of laboratory data obtained at baseline versus final in each group.

Variables	***p value - Groups***		
	Kcal Restriction (n:12)	**Low(n:9)**	**Fasting(n:9)**
Glucose	0,271	0,514	0,234
TC	0,005**	0,008**	0,008**
Tri	0,008**	0,008**	0,008**
HDL	0,002**	0,008**	0,008**
LDL	0,002**	0,008**	0,008**
VLDL	0,110	0,012**	0,008**

Subtitle: TC – Total cholesterol, Tri – Triglycerid, HDL – High-density lipoproteins, LDL – Low-density lipoproteins, VLDL – Very Low-density lipoproteins.
Source: Silvério AP, et al., 2023.

DISCUSSION

Body weight is influenced by different mechanisms, including hedonic regulation of food intake and homeostatic mechanisms that regulate short-term and long-term energy balance driven by hunger, satiety, and changes in adiposity. The consequence is that during and after weight loss, most individuals experience hypometabolism, hyperphagia, neuroendocrine alterations and autonomic alterations that act together to favor a return to normal body weight (SEID H and ROSENBAUM M, 2019).

As it can be seen in this research, body weight and BMI were reduced in all types of diet, as expected from the decrease in calories ingested. There was no statistical difference in weight loss between the groups studied, similar to other studies carried out. However, when the comparison was between initial and final body weight and initial and final BMI in the standard calorie restriction group (control) a significant difference was noted, thus showing this type of diet to be more efficient when these two parameters are analyzed. The calorie-restricted diet aims to reduce calorie intake and, as a consequence, lead to a decrease in blood glucose and consequent release of glucagon and other catabolic hormones, leading to lipolysis and proteolysis. In addition to this mechanism, the diet of eating every 3 hours did not allow the basal metabolism rate to decrease, thus generating greater loss of body weight. Statistical analyzes confirm that the basal metabolic rate did not decrease significantly (CERCATO C, 2016; CHRISTENSEN RAG, et al., 2021).

Weight loss through standard dietary restriction showed improved indicators of chronic disease risk. The main form of food restriction currently implemented is daily caloric restriction. These regimens consist of decreasing energy intake by 15–60% of basic needs each day. Although daily calorie restriction has been shown to be an effective weight loss strategy for certain segments of the obese population, many individuals have difficulty adhering to these diets (VARADY KA, et al., 2011).

When it comes to diets and cardiovascular risk, another important parameter is lean mass. Lean mass refers to muscle mass that uses glucose and lipids with a consequent decrease in blood glucose and lipemia. The high rate of the use of glucose and lipids by the muscle decreases the risk of cardiovascular diseases and diabetes. As found in the research, the calorie-restricted and low-carbohydrate diets did not lead to a significant loss of lean mass. Intermittent fasting, on the other hand, has been shown to lead to loss of lean mass, which can be explained by the activation of lipolysis and proteolysis necessary to maintain cell energy and normoglycemia (WILLOUGHBY D, et al., 2018). Lean body mass is usually maintained with intermittent fasting, including when followed by religious reasons and combined with resistance training. However, it is unclear if intermittent fasting inhibits lean body mass gain and it may depend on adequate protein supply and energy balance. The combination of intermittent fasting and resistance training can also lead to a reduction in body fat, not only during the apparent energy deficit, but also in the excess of energy. The volunteers in this research did not perform resistance physical exercises or supplementation with amino acids. This could be the explanation for the loss of lean mass in intermittent fasting (KEENAN S, et al., 2020).

The study of low-carbohydrate diets focused on weight loss in obese and overweight people, and in patients with or without risk of cardiometabolic disease. Ketogenic diets have been used for seizure disorders and in the athletic population for performance and health. Initial weight loss is due to water loss, but fat loss occurs with adherence to the approach. With all dietary interventions, as diet adherence declines, the weight loss effect becomes similar to other dietary approaches after one year (ASTRUP A and HJORTH MF, 2017).

Existing literature demonstrates that there are contradictory results regarding the results comparing the effectiveness of Intermittent Fasting and Low Carb Diet. Both interventions are shown to be effective for weight loss as long as there is a caloric deficit, which is usually potentiated when associated with physical activity. However, some results, like those found in the present study, show a difference in how the final objective, which is weight loss, is reached; that is, Low carb proved to be more efficient for absolute weight loss, while Intermittent Fasting showed less weight loss, but a greater decrease in fat percentage. Among the findings in the dietary approaches mentioned, there is an increase in symptoms related to weakness, irritability and mood changes, which can be decisive in maintaining the dietary plan, since many studies show a loss of adherence to the treatment of patients, due to difficulty with the aforementioned symptoms (NAZATTO MFS, et al., 2020; VARGAS AJ, et al., 2018).

Studies that aimed to compare anthropometric and biochemical changes, caused by the dietary intervention of Intermittent Fasting and Low Carb Diet, noted a similarity in the ability to reduce body mass, abdominal waist, fat percentage and even lean mass. The same can happen in relation to the biochemical parameters, which even with numerical differences in the improvement of the lipid profile, there are no great differences due to a statistical similarity in the values obtained (NAZATTO MFS, et al., 2020; MACHADO ACSB, 2016). Results from recent clinical studies have shown that low-calorie diets and intermittent fasting in obese patients can lead to a reduction in body fat mass and improvements in metabolic parameters. These beneficial effects arise not only from the loss of body mass, but also from the activation of metabolic pathways specific to fasting conditions, such as glucagon-stimulated lipolysis. Therefore, it is observed in the present article that there was a decrease in fat mass in relation to the diet control and intermittent fasting, this being not significant when comparing the values of the results between the groups, which shows that these diets are equally efficient in this parameter. This can be explained by the fact that the time of dietary restriction was the same short period of 30 days, but performed in different ways (ZUBRZYCKI A, et al., 2018).

Weight loss through caloric restriction, in the standard calorie-restricted and low-carbohydrate diet dietary interventions, was shown not to significantly change body cell mass. This is a strong suggestion that leads to the belief that with the adequacy of macro and micronutrients in the established diets, the higher protein intake associated with the caloric deficit were able to preserve body cell mass. It is known that adequate protein intake in balanced diets can alter body composition and promote greater energy expenditure in favor of a more fat-free body mass. The intermittent fasting intervention had a significant loss of total cell mass, coinciding with the loss of lean mass (muscle cells) and fat mass (adipocytes) (DE PERGOLA G, et al., 2020).

The volunteers of the present study were selected due to a high BMI with a consequent high rate of adipocytes. According to studies, adipocytes have a higher total body water content and also a higher extracellular water per unit of weight. Therefore, we can attribute part of the loss of extracellular water to the reduction in the number of adipocytes after the standard hypocaloric diet and low carb (SARTORIO A, et al., 2005). According to Welton, intermittent fasting showed weight loss of 0.8% to 13.0% in the 27 studies performed, regardless of changes in total caloric intake. Intermittent fasting is a favorable weight loss strategy, but its long-term use and health effects are not fully understood. Long-term studies are needed to understand how intermittent fasting can contribute to effective weight loss strategies. In this study, intermittent fasting showed significant calculated fat mass weight loss when compared between groups (WELTON S, et al., 2020).

As discussed above, basal metabolic rate did not decrease significantly on the standard calorie-restricted diet or on the low-carbohydrate diet due to shorter feeding intervals. When we talk about intermittent fasting, a significant decrease in basal metabolic rate is observed. The decrease in basal metabolic rate may represent a factor that leads the body to save energy and consequently lose less weight. More studies need to be conducted to unravel this connection (BONFANTI N, et al., 2014).

Body water showed significant changes along with body mass loss on the intermittent fasting diet. This water loss is an expected consequence of the ketogenicity-induced depletion of this type of food restriction, since glycogen stores are used to maintain adequate basal glucose and every gram of glycogen that was expended contains three grams of water. In addition, ketogenic agents decrease insulin stimulation and exert a rapid diuretic effect due to the decrease in the functioning of Sodium Glucose Linked Transporter (SLGT2) in the kidneys, which are partly stimulated by insulin, resulting in low sodium reabsorption and increased water excretion (KLEMENT RJ, et al., 2020).

Recently, low-carbohydrate diets have become a subject of international attention because of WHO recommendations to reduce the general consumption of fast-digesting sugars and starches. One of the most common metabolic changes that occur when a person follows a low-carb diet is ketosis. Low-carbohydrate intake results in a reduction in the level of circulating insulin, which generates exaggerated levels of circulating fatty acids used for oxidation and production of ketone bodies. It can be assumed that when available carbohydrate is reduced by a significant amount in a short period of time, the body will be stimulated to increase oxidation to obtain needed energy.

Current scientific literature shows that low carb diets acutely result in some effects such as decreased circulating glucose and fasting insulin, rapid weight loss, beneficial chances in blood pressure, and reduced triglyceride levels. However, some immediate harmful effects, such as loss of lean body mass, increased plasma homocysteine concentration and urinary calcium loss and increased low-density lipoprotein cholesterol, have been reported (ADAM-PERROT A, et al., 2006).

When laboratory biochemical parameters such as blood glucose and lipid profile are analyzed, this article shows that the decrease in the lipid profile was significant in all three interventions, so it can be observed that any of the diets have advantages over the reduction of cardiovascular risks (LANGSTED A and NORDESTGAARDN BG, 2019).

Acute disturbances in calorie intake, such as intermittent fasting, lead to changes in energy utilization; during fasting, free fatty acid mobilization, fatty acid oxidation and progressive increase in ketogenesis favor the conservation of glucose as its demand falls. During the subsequent refeeding period following fatty acid partitioning, postprandial whole-body fatty acid oxidation and hepatic ketogenesis remain, translating into a marked reduction in postprandial lipemia.

From a chronic perspective, these acute disturbances in food intake can cause very different changes in glucose and lipid metabolism. When compared to changes in blood glucose and lipid profile in intermittent fasting adherents, good results in total cholesterol, triglycerides, HDL, LDL and VLDL are remarkable, as evidenced by this research (ANTONI R, et al., 2017).

A low-carb diet has been shown to be effective in treating obesity and, in addition to significantly reducing weight, it can also effectively improve blood lipid and insulin resistance. In recent years, the American Diabetes Association and Diabetes UK have confirmed the effectiveness of a low-carbohydrate diet in reducing weight, improving blood glucose and regulating blood lipids in patients with DM. The low-carb diet in the present study showed reduction in blood glucose, total cholesterol, triglycerides, HDL, LDL and VLDL levels, thus showing a decrease in the risk of developing diabetes, metabolic syndrome, among other diseases (WANG LL, et al, 2018).

The insulin-carbohydrate model is based on the known action of insulin to increase cellular uptake of glucose and fatty acids, stimulate lipogenesis and inhibit lipolysis. According to this hypothesis, a high-carbohydrate diet stimulates insulin release and the resulting decrease in circulating glucose and free fatty acids is then detected by the central nervous system and other cellular systems that regulate energy homeostasis as a state of malnutrition. This invokes subsequent hypometabolism and hyperphagia, as well as preferential storage of ingested calories as fat. Clinically, the result is weight/fat gain and greater difficulty in controlling weight. Therefore, low-carbohydrate diets are biochemically interesting for fat control and consequent fat mass. In this study, taking into account the fat mass in the face of the low carb diet, this weight loss metabolism is confirmed with significance between initial and final weight, with carbohydrate restriction being an interesting strategy in weight loss (SEID H and ROSENBAUM M, 2019).

The study has as limitations the small number of participants, coverage of BMI for overweight and not just obesity, follow-up for a short period of time. Thus, needing further research.

CONCLUSION

The study presented three different types of food restriction, with weight and BMI reduction, as expected, in all of them. However, the standard calorie-restricted diet showed better results, especially in these parameters, which helps to control the patients' blood glucose and lipid levels. Regarding laboratory tests, the low-carbohydrate diet and intermittent fasting had good results with a reduction in blood glucose, total cholesterol, triglycerides, HDL, LDL and VLDL levels. Therefore, it can be concluded that any type of food restriction is accompanied by benefits for the patient. New research needs to be done to assess the composition of diets, changes when associated with physical activity, and short- and long-term metabolic changes to better understand their effects as effective weight loss strategies.

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