Capítulo 52

Role of the glycemic load profile on the dietary and cardiometabolic responses to an interdisciplinary weight loss program in women with obesity

Papel do perfil de carga glicémica nas respostas dietéticas e cardiometabólicas a um programa interdisciplinar de perda de peso em mulheres com obesidade

https://doi.org/10.56238/cienciasaudeestuepesv1-052

Carolina Kim Shiba
Post-Graduated Program of Nutrition. Paulista Medicine School. Universidade Federal de São Paulo (UNIFESP). São Paulo, Brazil

Raquel Munhoz da Silveira Campos
Department of Biosciences. Universidade Federal de São Paulo, Campus Baixada Santista. Santos, Brazil
Post Graduate Program of Interdisciplinary Health Sciences, Universidade Federal de São Paulo, Campus Baixada Santista, Santos - SP, Brazil

Samantha Ottani Rhein
Post-Graduated Program of Nutrition. Paulista Medicine School. Universidade Federal de São Paulo (UNIFESP). São Paulo, Brazil

Paola Próspero Machado
Post-Graduated Program of Nutrition. Paulista Medicine School. Universidade Federal de São Paulo (UNIFESP). São Paulo, Brazil

Lila Missae Oyama
Post-Graduated Program of Nutrition. Paulista Medicine School. Universidade Federal de São Paulo (UNIFESP). São Paulo, Brazil
Department of Physiology, Paulista Medicine School. Universidade Federal de São Paulo. São Paulo, Brazil

Lian Tock
Department of Physiology, Paulista Medicine School. Universidade Federal de São Paulo. São Paulo, Brazil

Gabriela Iervolino Oliveira
Obesity Study Group. Universidade Federal de São Paulo (GEO - UNIFESP). São Paulo, Brazil

Ana Raimunda Dâmaso
Post-Graduated Program of Nutrition. Paulista Medicine School. Universidade Federal de São Paulo (UNIFESP). São Paulo, Brazil

ABSTRACT
Background: "Ready-to-eat" or ultra-processed foods are commonly rich in refined sugar, sodium, energy density, saturated and trans fats, glycemic index (GI) and glycemic load (GL). Their consumption is strongly associated with obesity and metabolic syndrome (MS). *Objectives:* This study aimed to investigate the effect of an interdisciplinary weight loss program on women with obesity with an initially high versus low GL diet. *Methods:* 36 women with obesity and ages between 20 and 45 years old were enrolled in 12-week therapy, combining clinical, nutritional, physical exercise and educational eating. Body composition, quality, GL of diet, and metabolic profile were analyzed. *Results:* The volunteers were classified in two groups: 16 in moderate-elevate GL (ME-GL) group and 20 in the low GL (L-GL) group. The therapy promoted a significant reduction in the body composition parameters, including an increase in fat-free mass and resting metabolic rate (RMR) in the L-GL group, added to an increase in percentage of protein consumption. There was a drop in the value of HOMA-IR, and after therapy, 100% of the volunteers in the ME-GL group no longer had a MS, as well as 95% of the volunteers in the L-GL group. Besides that, cholesterol levels were adjusted, and consumption of sodium decreased, reducing the risk for hypertension and cardiometabolic diseases. *Conclusions:* The interdisciplinary weight loss program showed to be effective on improvement of body composition, insulin resistance, on the treatment of MS, and a greater improvement in lipids profile, preventing cardiometabolic risks in a sample of women with obesity.

Keywords: obesity, women, treatment of obesity, glicemic load, inflammation

RESUMO
Antecedentes: Os alimentos "prontos a comer" ou ultra-processados são normalmente ricos em açúcar

refinado, sódio, densidade energética, gorduras saturadas e trans, índice glicémico (IG) e carga glicémica (GL). O seu consumo está fortemente associado à obesidade e à síndrome metabólica (EM). Objectivos: Este estudo visou investigar o efeito de um programa interdisciplinar de perda de peso em mulheres com obesidade com uma dieta inicialmente alta versus baixa GL. Métodos: 36 mulheres com obesidade e com idades compreendidas entre os 20 e 45 anos foram inscritas em terapia de 12 semanas, combinando exercícios clínicos, nutricionais, físicos e alimentação escolar. A composição corporal, qualidade, GL da dieta, e perfil metabólico foram analisados. Resultados: Os voluntários foram classificados em dois grupos: 16 no grupo de GL moderada (ME-GL) e 20 no grupo de GL baixa (L-GL). A terapia promoveu uma redução significativa dos parâmetros de composição corporal, incluindo um aumento da massa sem gordura e da taxa metabólica em repouso (RMR) no grupo L-GL, adicionado a um aumento na percentagem do consumo de proteínas. Houve uma queda no valor do HOMA-IR, e após a terapia, 100% dos voluntários do grupo ME-GL já não tinham EM, bem como 95% dos voluntários do grupo L-GL. Além disso, os níveis de colesterol foram ajustados, e o consumo de sódio diminuiu, reduzindo o risco de hipertensão e doenças cardiometabólicas. Conclusões: O programa interdisciplinar de perda de peso mostrou ser eficaz na melhoria da composição corporal, resistência à insulina, no tratamento da EM, e uma maior melhoria no perfil lipídico, prevenindo riscos cardiometabólicos numa amostra de mulheres com obesidade.

Palavras-chave: obesidade, mulheres, tratamento da obesidade, carga glicémica, inflamação

1 INTRODUCTION

According to the World Health Organization (WHO), obesity is defined by an excess of body fat that has damageable health effects [(1)]. Obesity affects both men and women, with the highest prevalence in women who present important gender specificities, leading to particular attentions to their impact on obesity-related comorbidities, such as type 2 diabetes mellitus (T2D), cardiovascular disease, hypertension, nonalcoholic fatty liver disease (NAFLD), cancers, and reproductive and gynaecologic health [(2,3,4)].

The pathophysiology and management of obesity and visceral fat accumulation is important to preserve individuals' quality of life, physiological and metabolic health and then to prevent the development of chronic diseases [(1-6)].

Changes in the global food system in the last few decades has been favouring the incidence and prevalence of excess body weight. The increasing availability of processed food has lengthened the products shelf life and reduced their costs, which was however accompanied by some changes of the composition, mainly addition of salt, sugars, fat, and additives. Such methods are creating energy-dense and nutritionally imbalanced foods [(7)].

In their study, Nazmi et al. [(8)] showed a strong relationship between the consumption of ultra-processed foods and obesity, hypertension, and metabolic syndrome. Low physical activity has also been reported to increase the risk of obesity and metabolic syndrome. Modifying individuals' consumption of such ultra-processed food (UPF) might then be an interesting strategy to favour weight loss and improve patients' metabolic healthy [(4,9)].

According to Clamp et al. [(10)], weight loss is difficult to achieve and maintain, therefore, it is interesting to focus on strategies to prevent regaining weight. With the decrease in caloric consumption and

the consequent decrease in body weight, it is expected that there will be a reduction in the resting metabolic rate (RMR), which may imply a future regain of weight. Thus, dietary interventions combined with physical activity programs are highly effective in the weight loss process contributing to the maintenance and increase of the RMR preserving fat-free mass, such as organs and muscles, which are metabolically active tissues [10-12].

"Ready-to-eat" foods or ultra-processed foods are commonly rich in refined sugar, sodium, energy density, saturated and trans fats, and with high glycemic index (GI) and glycemic load (GL). On the other hand, they contain low amounts of fibers, protein and micronutrients [11,13]. The GI provides information on the glycemic response that is expected when a person consumes a food containing carbohydrate. The GL is defined as a predictor of the postprandial glycemic and insulin in response of the food's carbohydrate content. It is important to identify the contribution of GI and GL to the development of components of MetS, such as, insulin resistance, central obesity, dyslipidemia, DM2, and hypertension [14].

Since the prevalence of overweight and obesity is increasing, finding modifiable risk factors of obesity, including dietary GI and GL, is of high priority. The relation of GI and GL to obesity remains unclear and under-explored. Although the quantity and the quality of the ingested carbohydrate is relevant to the evolution of obesity [15]; according to Ludwig et al. [16], the GL is the best single predictor of postprandial blood glucose levels.

In that context, the aim of the present study was to assess the efficacy on an interdisciplinary weight loss intervention of the cardiometabolic health of women with obesity, depending on their baseline Glycemic load profile.

2 MATERIAL AND METHODS

Research design

Population

Thirty-six women with obesity, classified according to the WHO were recruited from ads published in different media (newspapers, magazines, radio, television, and Instagram®), during the period of March to May 2018. To be included, the participants had to i) live in the city of São Paulo or nearby, so they could attend meetings; ii) be aged between 20 and 45 years old; iii) present a Body Mass Index (BMI) above 30 kg/m²; iv) had to be free of any diseases that could interfere the weight loss therapy, such as, heart disease, musculoskeletal deformities, diseases related to the immune system, genetic, metabolic, or endocrine diseases.

Once a month, the volunteers had sessions of clinical, nutritional, physical exercise and educational eating, supporting adherence. Furthermore, the women had access to the #12Semanas® Platform, to complete the Education Behaviors Program.

This interdisciplinary therapy with clinical approach, nutritionist, and exercise physiologist, was approved by the Ethics and Research Committee of the Federal University of São Paulo (CEP nº 1277/2020). The clinical trial registration number is NCT04034472.

Anthropometric measures and body composition

The body mass was measured using light clothes and barefoot on a Filizola® (Brazil, São Paulo). Mechanical anthropometric scale, with a maximum capacity of 150kg and a sensitivity of 100g. Moreover, height was measured with a Sanny® brand stadiometer (Brazil, São Paulo) with a precision scale of 0.1 cm. Subsequently, the body mass index (BMI) was calculated.

Neck, waist, abdominal and hip circumferences were measured with a flexible and inelastic tape. Body composition, including measure of fat mass (% and kg), free fat mass (kg) and resting metabolic rate (RMR) were measured by Bio-impedance meter (BIA) provided by the device BIODYNAMICS 310e (TBW®) (EUA, Shoreline).

Serum Analysis

Blood samples were collected after an overnight 12-hour fast at the beginning and after 12-weeks of intervention. Concentrations of glucose, insulin, triglycerides (TG), total cholesterol (TC), cholesterol fractions and hepatic transaminases: alanine aminotransferase (ALT), aspartate aminotransferase (AST) and gamma glutamyl transferase (GGT) were determined by enzymatic colorimetric methods (CELM) immediately after blood collection.

Homeostasis model assessment for insulin resistance (HOMA-IR) was uses to determinate insulin resistance (IR), that was calculated by the following formula: [fasting glucose (mmol / L) x fasting insulin (µU / L)] / 22.5. According to the cutoff point determined for the Brazilian population, HOMA-IR values above 2.71 were considered as indicators of IR [17].

Glycemic Load classification

The GI is a tool that provides information on the glycemic response that is expected when a person consumes a food containing carbohydrate. The concept of GL was created to predict the glycemic response. It considers the GI and the amount of available carbohydrate in a portion of the food eaten (GL = GI x available carbohydrate in each amount of food). Foods have been classified by GI into low (GI ≤ 55), medium (GI 56–69), and high (GI ≥ 70) categories, and classified by GL as being low (GL ≤ 10), medium (GL 11–19), and high (GL ≥ 20) [18].

Metabolic Syndrome diagnosis

According to International Diabetes Federation (IDF) [19], the diagnosis of MetS in women includes the presence of abdominal obesity (waist circumference: > 80cm) along with the presence of two or more

of the following: a) blood glucose greater than 100mg/dl, b) HDL cholesterol < 50mg/dl, c) blood triglycerides > 150 mg/dl and/or d) blood pressure > 130/85 mmHg [20].

Interdisciplinary Therapy

After the volunteer's recruitment process, these women were submitted to 12 weeks of interdisciplinary therapy to weight loss and change the lifestyle. At the baseline and after therapy the volunteers were examined by the health professionals including endocrinologist, nutritionist, and exercise physiologist. The aim of the research was to observe a reducing body weight of 5 to 10% with changes in eating habits and physical exercise taught during treatment.

Clinical therapy

The medical follow-up involved the initial clinical history, physical examination of blood pressure; cardiac frequency and body composition were checked for their adherence to all interdisciplinary therapies. The voluntaries received two medical supports, at baseline and by the end of the interdisciplinary therapy.

Nutritional therapy

Before the volunteers started the program, they had to fill in some questionnaires, such as, three-day food record and food frequency questionnaire, so we could analyze and understand their eating habits and preferences as well as the quality of their food intake.

According to the results of RMR evaluated by Bio-impedance, the volunteers were separated into four groups, which were categorized by the need for caloric intake: group 1 (RMR between 1400 to 1600 kcal/day, received a nutritional guidance of 1400 kcal/day); group 2 (RMR between 1600 to 1800 kcal/day, received a nutritional guidance of 1600 kcal/day); group 3 (RMR between 1800 to 2000 kcal/day, nutritional guidance of 1800 kcal/day); group 4 (RMR > 2000 kcal/day, nutritional guidance of 2000 kcal/day). The distribution of food groups was based on the recommendation of FAO/ WHO [21]: proteins (10-15%), lipides (15-30%) and carbohydrates (55-75%).

The energy intake was established according to Dietary Reference Intakes (DRI)[21], considering physical activities levels, age, and sex. The questionaries were responded at the baseline and post therapy. The responses of three-day food record were transferred to a computer and analyzed by a nutritionist using the program Diet Smart (Diet Smart Copyright ©, 2012-2018).

Physical activity

At baseline, the volunteers had to complete the International Physical Activity Questionnaire (IPAQ) – short version. During the twelve-week therapy, the volunteers received weekly physical exercises orientations by web site, with demonstrative videos with exercises and educational text in view to improve lifestyle (>150min/week). The exercise program included endurance, resistance, flexibility, and balance.

Body composition variables and basal metabolic rate were used by the physiologist to individualize the program, propose to participants activities that they like and then improve their adhesion. The program follows the recommendations given by the American College of Sports Medicine (ACSM) [23].

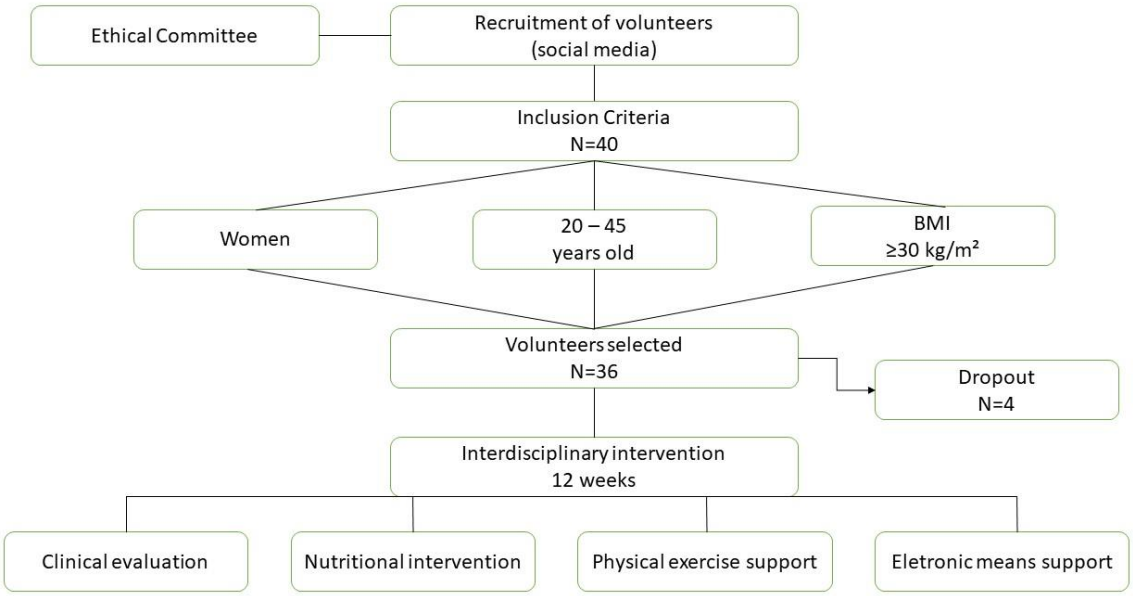
Topics covered via the website

In the *Web* support, weekly motivational conversations between the Exercise Physiologist, Nutrition Professional and the volunteers was made through conversations via chat, WhatsApp® groups, aiming improvement of the results. Besides, videos and explanatory texts on various themes was included:

1) nutrition, physical exercise, and motivation;
2) aesthetics is the consequence of the search for health;
3) sedentary lifestyle can increase expression of a gene responsible for obesity;
4) learn to choose physical exercise according to your identity;
5) make the right choice and learn to eat healthy;
6) use the food pyramid in your favor;
7) the importance of dietary fractionation;
8) learn how to assemble your dish by combining foods efficiently;
9) slow chewing is one of the steps to weight loss success;
10) learn to ingest water.

In addition, the volunteers were asked to fill out the session weekly for the professionals to observe how they were involved and to allow interactions with the other volunteers as motivational strategies (Figure 1).

Figure 1. Methodological design of the interdisciplinary clinical approach to improve health habits in women with obesity.



3 STATISTICAL ANALYSIS

Statistical analyses were performed using SPSS 21.0 software (SPSS Inc., Chicago, Illinois, USA). Repeated measures to compare baseline and after intervention were performed through generalized equation estimate (GEE) using gamma distribution determined by Quasi Likelihood under Independence Model Criterion (QIC) and Sidak post hoc was used to pairwise comparisons. A generalized linear model (GzLM) using gamma distribution determined by Akaike information criterion (AIC) was used to determine the differences between groups in delta values and Sidak post hoc was applied to pairwise comparisons. Regression analysis was applied to investigate the association among macronutrients consumption with Glycemic Load. Statistical significance was considered when $p \leq 0.05$. The groups were divided by the Glycemic Load in moderate-elevate glycemic load (ME-GL) (n= 16) and low glycemic load (L-GL) (n=20). Prevalence of metabolic syndrome was evaluated by McNemar's test.

4 RESULTS

Effects of interdisciplinary therapy in entire group

The total sample (n=36) showed reduction in body mass (kg), BMI (kg/m²), neck, waist, abdominal and hip circumferences (cm), waist/hip ratio and body fat mass (%). For free fat mass (kg) and RMR (kcal/day) no statistically significant changes were observed (table1). Moreover, glucose (mg/dL), insulin (uIU/mL), total cholesterol (mg/dL), HDL cholesterol (mg/dL), non-HDL cholesterol (mg/dL) and LDL cholesterol (mg/dL) concentrations were reduced. For HOMA-IR, VLDL cholesterol (mg/dL), tryglicerides (mg/dL), and hepatic enzymes no changes were observed (table 2).

Considering the nutritional profile, after the weight loss therapy, reductions were observed for: calories intake (kcal/day), carbohydrate (g and %), fibers (g), protein (g), lipides (g), saturated, monounsaturated, and polyunsaturated fat (g), cholesterol intake (g), sodium (mg), calcium (mg), iron (mg) and glycemic load. On the other hand, there was a significant increase in protein (%). For lipids (%), folic acid (mcg), zinc (mg), copper (mg), selenium (mcg) and the glycemic index no difference was observed (table 3). In the present study it was showed a dropout of 4 volunteers, the major reasons for dropout were family and financial problems, followed by job opportunities.

Effects of the interdisciplinary therapy in the moderate-elevate glycemic load (ME-GL) group

In the ME-GL group, all the parameters showed significant improvement, including reductions in body mass (kg), BMI (kg/m²), neck, waist, abdominal and hip circumferences (cm), waist/hip ratio, body fat mass (%), free fat mass (kg) and RMR (kcal/day). Considering the metabolic profile, it was demonstrated reduction in glucose (mg/dL), insulin (uUI/mL) and in HOMA-IR. For total cholesterol (mg/dL), HDL cholesterol (mg/dL), non-HDL cholesterol (mg/dL), LDL cholesterol (mg/dL), VLDL cholesterol (mg/dL), tryglicerides (mg/dL), AST (U/L), ALT (U/L) and GGT (U/L) no changes were observed (table 2).

For the nutritional profile there were reduction in calories intake (kcal/day), carbohydrate (g and %), fibers (g), protein (g), lipides (g), saturated and polyunsaturated fat (g), sodium (mg), calcium (mg), iron (mg), zinc (mg) and glycemic load. Only protein (%) showed an increase after intervention. No significant changes were observed for glycemic index, monounsaturated fat, cholesterol intake, folic acid (mcg), copper (mg) and selenium (mcg) (table 3).

Effects of interdisciplinary therapy in low glycemic load (L-GL) group

In the L-GL group, there were reductions in body mass (kg), BMI (kg/m²), neck, waist, abdominal and hip circumferences (cm), and body fat mass (%). No statistically significant changes were showed for lean mass (kg), RMR (kcal/day) and waist/hip ratio (table 1).

The insulin (uUI/mL), total cholesterol (mg/dL) and HDL cholesterol (mg/dL) were significantly reduced during therapy. No difference was observed for glucose (mg/dL), HOMA-IR, non-HDL cholesterol (mg/dL), LDL cholesterol (mg/dL), VLDL cholesterol (mg/dL), tryglicerides (mg/dL) and hepatic enzymes (table 2).

Moreover, there was a significant reduction in calories intake (kcal/day), carbohydrate (g), lipides (g), saturated and monounsaturated fat and sodium (mg). On the other hand, the protein (%) increased statistically. No difference was observed for the variables folic acid (mcg), zinc (mg), copper (mg), selenium (mcg), glycemic index carbohydrate (%), fibers (g), protein (g), lipids (%), polyunsaturated fat, cholesterol intake, calcium (mg), iron (mg) and glycemic load (table 3).

Analysis of intervention magnitude according to the glycemic load groups.

According to the delta values analysed for anthropometric parameters, body composition and the metabolic profile, no difference was showed between groups as detailed in tables 4 and 5. However, delta values for dietary parameters showed that the ME-GL group had the greatest reduction in calories intake (kcal/day), carbohydrates (g), protein (g), folic acid (mg), iron (mg), zinc (mg), cooper (mg) and glycemic load; indeed, the lipids (%) had increased when compared with L-GL group (table 6).

Association among Glycemic Load and nutritional components

In the regression analysis, according to the different models used, carbohydrates (g), proteins (g) and lipids (g) are positively related to the increase of the glycemic load. In contrast, the fibers (g) are negatively associated with this glycemic load (table 7).

Prevalence of Metabolic Syndrome according to the glycemic load groups

The prevalence of metabolic syndrome in the low glycemic group was 25% at baseline and decreased to 5% after the therapy. While in the moderate-elevate glycemic load 12.5% had a metabolic syndrome at baseline and at the end of treatment, no volunteers had metabolic syndrome (figure 2).

5 DISCUSSION

This study aimed to investigate the impact of interdisciplinary therapy on eating behaviours and the cardiometabolic profile of women with obesity, depending on their glycemic load. The major findings of the present investigation were that this therapy promoted a significant reduction in the body composition parameters, with however an increase of FFM and RMR in the L-GL group only (table 1). We also observed a significant increase of the percentage of protein intake in the entire group after nutritional interventions (table 3).

In the weight loss process a decrease in fat-free mass and RMR is expected, according to Cava E. et al. [24], 1.25 to 1.5 times the RDA of proteins for sedentary people, are recommended for people with obesity who undergo weight loss therapies to limit weight loss of muscle mass.

Including physical exercise into weight loss interventions helps to maintain or even increase the levels of free fat mass, which is a metabolic active tissue and the major determinant of RMR [6,25].

Another important finding is that there was a significant drop in the value of HOMA-IR, leading to a normalisation of its concentration (<2.71) in the ME-GL group; and to values close to what is recommended in L-GL group. Corroborating this, the figure 2 shows that at after the therapy, 100% of the volunteers in the ME-GL group no longer have a MS, as well as 95% of the volunteers in the L-GL group, confirming the beneficial effects of such interventions.

Besides the improvements in body composition, the proposed therapy proved to be effective in improving biochemical values, such as, glucose values in entire and ME-GL groups, insulin in all groups, HOMA-IR in ME-GL group, total cholesterol in entire and L-GL groups, non-HDL cholesterol in entire group and LDL cholesterol in entire group, which is important for the diagnosis of MS.

In addition, we had a significant reduction in GL in the ME-GL group, which may be related to the amount that decreased of carbohydrate consumption (g) - (45.5% and 40.6% respectively). The reduction of glucose and insulin is also related to this since the concept of GL was created to predict the glycemic response and it considers the GI and the amount of available carbohydrate in a portion of the food eaten. Moreover, in table 7 we can see a positive relationship between carbohydrate consumption and GL, on the other hand, a negative relationship between fibers consumption and GL, reinforcing the importance of fibers consumption in the weight loss process, which according to Dietary Reference Intakes (DRIs), the recommendation is 25g/day.

The high prevalence of obesity is mainly due to a physical inactivity and inadequate eating habits, especially the ultra-processed foods, foods with high glycemic index and load generating a positive energy balance and a pro-inflammatory state. According to Salari-Moghaddam et al.[26], these kinds of foods, tends to contain fewer amounts of vegetables, legumes, whole grains, and nuts, in other words, greater amounts of food with less supply of vitamins.

The dietary interventions and strategies are an effective and safe way to prevent and manage obesity [27]. Our study showed an improvement of diet habits, mainly considering the reduction in calories intake,

carbohydrates (g), lipids (g), saturated fat, and sodium in all groups, carbohydrate (%) and GL has improved mainly in entire and ME-GL groups.

Moreover, the therapy was effective in reducing the saturated fat intake, which is recommended by the American Food Guide a maximum of 10% of the total calories of the day [28]. Unfortunately, monounsaturated and polyunsaturated fat had a significant decrease at the end of treatment. These fatty acids are found in plants, such as chia, canola seed and in some fish, and they have a beneficial effect for our health and prevent diseases [29]. However, even then, the volunteers, maintained HDL cholesterol level values within the recommendation (>40 mg/dL), avoiding greater risks for cardiovascular disease [30].

The weight loss program was effective in decreasing sodium in all groups, reducing the risk for diseases associated with obesity, such as hypertension, coronary and kidney diseases, that are risk factors for MS diagnosis. According to Susic D. and Varagic J.[31], overweight is responsible for 65-75% of primary hypertension, therefore, reducing the consumption of these nutrient is essential. The World Health Organization recommends eating a maximum of 2g of sodium, equivalent to 5 grams of salt per day [32,33].

However, there was some decreases that brings negative effects, such as reducing fibers, folic acid, calcium, and iron. Dietary fibers are present in some fruits, vegetables, oats, whole-grains, nuts and seeds. Guidance is needed so that the amount of fiber is not out of step in the weight loss process.

In all groups analysed, the amount of folic acid was below the recommended amount per day (400mcg/d, according to DRI), however it is important to highlight that the L-GL group showed increased of this variable after the intervention. Its deficiency can appear for several reasons, including an inadequate diet, with low consumption of fruits, vegetables and green leaves, and the destruction of folic acid with the heat of cooking [34]. In Table 6 we can observe that folic acid values can increase with adjustments in eating habits. The same succeeded with zinc, copper, and selenium delta values.

The recommendation of calcium intake is 1000mg/day according to DRIs. It is implicated to be involved in prevention or treatment of obesity, reducing blood pressure, LDL-cholesterol and increasing HDL-cholesterol values by inhibiting cholesterol and saturated fatty acid absorption [35]. The L-GL group maintained the quantity of the calcium intake, because they must had a better adherence to a diet rich in dark green leaves, seeds, grains, and dairy products, like milk and yogurt, that are sources of calcium. This fact is related to the increase in the amount of folic acid in the L-GL group as well, since the source foods are similar.

The deficiency of iron is associated with pathological conditions, such as obesity, especially after bariatric surgery due to impaired global absorption food is the only source of iron for the human body [36-38]. In our study, the L-GL had better results, with an insignificant decrease in relation to the initial value, but still, all values are below the recommended (18 mg/d, according to DRI).

No significant alterations were observed in hepatic enzymes, however, it is important to reinforce that for all hepatic enzymes investigated, the values are in accordance with the reference for the investigate population, suggesting no risk for non-alcoholic liver steatosis [39].

Some limitations of the present study are the small sample size, the short intervention period (only 12 weeks), the lack of control group and the records of physical activity. Second, the Brazilian database is not complete with the 45 food parameters to calculate. Third, there may be a margin of error in bioimpedance RMR results.

In summary, the therapy seems to be effective in the weight loss process, improving macronutrients in the diet, body composition and biochemical profile, reducing risks for cardiovascular diseases in women with obesity. Furthermore, is still needed to adjust the amounts of micronutrients, such as vitamins and minerals.

6 CONCLUSION

The present study showed that the interdisciplinary therapy, intervening eating habits and physical activity have a great impact in low glicemic load of diet by improving macro and micronutrients and metabolic profile, preventing cardiometabolic risk and metabolic syndrome in a sample of women with obesity.

In a long-term clinical treatment, it is important to continue to focus on maintaining lean mass and RMR to improve the weight loss and avoid the regain, as well as having a constant analysis of consumption of vitamins and minerals to adjust according to the recommendations.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was supported by the Foundation of São Paulo Research - FAPESP (grant nos.: 2017/07372-1, Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP), the National Council for Scientific and Technological Development - CNPq (grant nos.: 301322/2017-1) and the Coordination of Higher Educational Personnel Training – CAPES.

ACKNOWLEDGEMENTS

CKS: Substantial contributions to conception and design, data acquisition, analysis and/or interpretation; Drafting the article with important intellectual content; **RMSC**: Substantial contributions to design, analysis and interpretation; Critical revision with important intellectual content; **ACPK**: Substantial contributions with the interpretation of the findings and critical revision with important intellectual content; **SOR**: Substantial contributions to conception and design, data acquisition; **PPM:** Substantial contributions to conception and design, data acquisition; **LMO:** Substantial contributions to biochemical analysis and interpretation of the findings; **LLD:** Medical support with substantial contributions during the data acquisition; **LT:** Medical support with substantial contributions during the data acquisition; **GIO:** Medical support with substantial contributions during the data acquisition; **DT:** Contributed with the interpretation of the findings and critical revision with important intellectual content; **ARD:** Substantial contributions to

conception and design, data acquisition, analysis and/or interpretation; Drafting the article and critical revision with important intellectual content. All authors read and approved the final version of the manuscript and are in agreement to be accountable for all aspects of the work

The authors have no financial or personal conflicts of interest to declare.

REFERENCES

Organização Mundial da Saúde. Dia mundial da obesidade. March 2020; Available from: http://bvsms.saude.gov.br/.

Kapoor E, Faubion SS, Kling JM. Obesity Update in Women. *J Womens Health (Larchmt)*. Published online: 28 December 2019. doi: 10.1089/jwh.2019.8041.

Tauqeer Z, Gomez G, Stanford FC. Obesity in Women: Insights for the Clinician. *J Womens Health (Larchmt)*. Published online: 27 April 2018. doi: 10.1089/jwh.2016.6196.

Mundi MS, Velapati S, Patel J, Kellogg TA, Abu Dayyeh BK, Hurt RT. Evolution of NAFLD and Its Management. Nutr Clin Pract. 2020 Feb;35(1):72-84. doi: 10.1002/ncp.10449. Epub 2019 Dec 16. PMID: 31840865.

Chooi YC, Ding C, Magkos F. The epidemiology of obesity. *Metabolism.* Published online: 22 September 2019. doi: 10.1016/j.metabol.2018.09.005.

Oussaada SM, van Galen KA, Cooiman MI et al. The pathogenesis of obesity. *Metabolism.* Published online: 9 January 2019. doi: 10.1016/j.metabol.2018.12.012.

Nardocci M, Leclerc BS, Louzada ML et al. Consumption of ultra-processed foods and obesity in Canada. *Can J Public Health.* Published online: February 2019. doi: 10.17269/s41997-018-0130-x.

Nazmi A, Tseng M, Robinson D et al. A Nutrition Education Intervention Using NOVA Is More Effective Than MyPlate Alone: A Proof-of-Concept Randomized Controlled Trial. *Nutrients.* Published online: 6 December 2019. doi: 10.3390/nu11122965.

Khandpur N, Neri DA, Monteiro C et al. Ultra-Processed Food Consumption among the Paediatric Population: An Overview and Call to Action from the European Childhood Obesity Group. *Annals of Nutrition Metabolism*. Published online: 28 April 2020. doi: 10.1159/000507840.

Clamp LD, Hume DJ, Lambert EV et al. Successful and unsuccessful weight-loss maintainers: strategies to counteract metabolic compensation following weight loss. *J Nutr Sci*. Published online: 28 June 2018. doi: 10.1017/jns.2018.11.

Livesey G, Taylor R, Livesey HF et al. Dietary Glycemic Index and Load and the Risk of Type 2 Diabetes: A Systematic Review and Updated Meta-Analyses of Prospective Cohort Studies. *Nutrients.* Published online: 5 June 2019. doi: 10.3390/nu11061280.

Balani R, Herrington H, Bryant E et al. Nutrition knowledge, attitudes, and self-regulation as predictors of overweight and obesity. *J Am Assoc Nurse Pract.* Published online: 3 September 2019. doi: 10.1097/JXX.0000000000000169.

Askari M, Heshmati J, Shahinfar H et al. Ultra-processed food and the risk of overweight and obesity: a systematic review and meta-analysis of observational studies. *Int J Obes (Lond)*. Published online: 14 August 2020. doi: 10.1038/s41366-020-00650-z.

Zhang JY, Jiang YT, Liu YS, et al. The association between glycemic index, glycemic load, and metabolic syndrome: a systematic review and dose-response meta-analysis of observational studies. *Eur J Nutr*. Published online: March 2020. doi: 10.1007/s00394-019-02124-z.

Salari-Moghaddam A, Keshteli AH, Haghighatdoost F et al. Dietary glycemic index and glycemic load in relation to general obesity and central adiposity among adults. *Clin Nutr*. Published online: 6 January 2019. doi: 10.1016/j.clnu.2018.12.036.

Ludwig DS, Ebbeling CB. The Carbohydrate-Insulin Model of Obesity: Beyond "Calories In, Calories Out". *JAMA Intern Med*. Published online: 1 August 2018. doi: 10.1001/jamainternmed.2018.2933.

Fernström M, Fernberg U, Hurtig-Wennlöf A. Insulin resistance (HOMA-IR) and body fat (%) are associated to low intake of fruit and vegetables in Swedish, young adults: the cross-sectional lifestyle, biomarkers and atherosclerosis study. *BMC Nutr*. Published online: 20 February 2019. doi: 10.1186/s40795-019-0279-6.

Vega-López S, Venn BJ, Slavin JL. Relevance of the Glycemic Index and Glycemic Load for Body Weight, Diabetes, and Cardiovascular Disease. *Nutrients.* Published online 22 September 2018. doi: 10.3390/nu10101361.

International Diabetes Federation, 2006.

Saklayen MG. The Global Epidemic of the Metabolic Syndrome. *Curr Hypertens Rep.* Published online: 26 February 2018. doi: 10.1007/s11906-018-0812-z.

Food and Agriculture Organization of the United Nations. Human vitamin and mineral requirements. 2003.

Institute of Medicine. Dietary reference intakes: applications in dietary planning. Washington (DC): National Academy Press; 2003.

Niemiro GM, Rewane A, Algotar AM (2020) Exercise and Fitness Effect On Obesity. *StatPearls [internet]*.

Cava E, Yeat NC, Mittendorfer B. Preserving Healthy Muscle during Weight Loss. *Adv Nutr*. Published online: 15 May 2017. doi: 10.3945/an.116.014506.

Abe T, Dankel SJ, Loenneke JP. Body Fat Loss Automatically Reduces Lean Mass by Changing the Fat-Free Component of Adipose Tissue. *Obesity (Silver Spring).* Published online: 31 January 2019. doi: 10.1002/oby.22393.

Salari-Moghaddam A, Saneei P, Larijani B et al. Glycemic index, glycemic load, and depression: a systematic review and meta-analysis. *Eur J Clin Nutr*. Published online: March 2019. doi: 10.1038/s41430-018-0258-z.

Nicholls SJ, Nelson AJ. HDL and cardiovascular disease. *Pathology.* Published online: 3 January 2019. doi: 10.1016/j.pathol.2018.10.017.

Zhang F, Ye J, Zhu X et al. Anti-Obesity Effects of Dietary Calcium: The Evidence and Possible Mechanisms. *Int J Mol Sci*. Published online: 23 June 2019. doi: 10.3390/ijms20123072.

Heileson JL. Dietary saturated fat and heart disease: a narrative review. *Nutr Rev.* Published online: 1 June 2020. doi: 10.1093/nutrit/nuz091.

Shahidi F, Ambigaipalan P. Omega-3 Polyunsaturated Fatty Acids and Their Health Benefits. *Annu Rev Food Sci Technol*. Published 25 March 20181. doi: 10.1146/annurev-food-111317-095850.

Grillo A, Salvi L, Coruzzi P et al. Sodium Intake and Hypertension. *Nutrients.* Published 21 August 2019. doi: 10.3390/nu11091970.

Susic D, Varagic J. Obesity: A Perspective from Hypertension. *Med Clin North Am*. 2017 Published online: January 2017. doi: 10.1016/j.mcna.2016.08.008.

Hall JE, do Carmo JM, da Silva AA et al. Obesity, kidney dysfunction and hypertension: mechanistic links. *Nat Rev Nephrol*. Published online: June 2019. doi: 10.1038/s41581-019-0145-4.

Khan KM, Jialal I (2020) Folic Acid Deficiency. *StatPearls* [Internet].

Cormick G, Belizán JM. Calcium Intake and Health. *Nutrients.* Published online: 15 July 2019. doi: 10.3390/nu11071606.

Śliwińska A, Luty J, Aleksandrowicz-Wrona E et al. Iron status and dietary iron intake in vegetarians. *Adv Clin Exp Med.* Published online: October 2018. doi: 10.17219/acem/70527.

Camaschella C. Iron deficiency. *Blood.* Published online: 3 January 2019. doi: 10.1182/blood-2018-05-815944.

González-Domínguez Á, Visiedo-García FM, Domínguez-Riscart J et al. Iron Metabolism in Obesity and Metabolic Syndrome. *Int J Mol Sci.* Published online: 1 August 2020. doi: 10.3390/ijms21155529.

Lala V, Goyal A, Bansal P et al (2020) Liver Function Tests. *StatPearls* [Internet].

ANEXOS

Table 1. Analysis the effects of intervention according to glycemic load groups. Anthropometric and body composition parameters

Variables	All (n= 36)				moderate-elevate glycemic load (n=16)				low glycemic load (n=20)			
	baseline		after therapy		baseline		after therapy		baseline		after therapy	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
body mass (kg)	96.26	± 18.44	90.54	± 17.77 [A]	94.78	± 15.06	88.30	± 15.31 [A]	97.44	± 21.08	92.33	± 19.72 [A]
BMI (kg/m²)	35.90	± 6.16	33.76	± 5.96 [A]	34.90	± 5.65	32.49	± 5.63 [A]	36.71	± 6.57	34.78	± 6.16 [A]
neck circumference (cm)	36.53	± 2.20	35.12	± 1.92 [A]	36.53	± 1.92	34.99	± 1.69 [A]	36.52	± 2.46	35.23	± 2.12 [A]
waist circumference (cm)	97.63	± 9.45	91.69	± 7.45 [A]	97.97	± 8.44	91.33	± 8.52 [A]	97.37	± 10.39	91.99	± 6.68 [A]
abdominal circumference (cm)	109.97	± 9.87	104.86	± 9.84 [A]	109.38	± 11.07	103.41	± 10.59 [A]	110.45	± 9.07	106.03	± 9.30 [A]
hip circumference (cm)	122.27	± 13.10	117.82	± 12.74 [A]	119.86	± 10.81	114.61	± 9.60 [A]	124.20	± 14.67	120.38	± 14.51 [A]
waist/hip ratio	0.80	± 0.07	0.78	± 0.06 [A]	0.82	± 0.07	0.80	± 0.06 [A]	0.79	± 0.06	0.77	± 0.06
fat mass (%)	39.84	± 4.38	37.14	± 5.14 [A]	39.06	± 4.14	36.15	± 5.54 [A]	40.46	± 4.57	37.93	± 4.78 [A]
free fat mass (kg)	57.48	± 7.01	56.92	± 10.31	57.26	± 6.11	55.73	± 6.29 [A]	57.66	± 7.82	57.88	± 12.75
RMR (kcal/day)	1747.56	± 213.43	1739.33	± 310.25	1740.63	± 185.68	1694.38	± 191.10 [A]	1753.10	± 237.94	1775.30	± 381.33

BMI: body mass index; RMR: resting metabolic rate

Generalized estimating equation (GEE) post hoc Sidak with Gama distribution. Statistical significance $p \leq 0.05$

[A]Statistical difference between baseline and after intervention

Reference values: Body mass index (18.5 – 24.9 kg/m²); waist/hip ratio (<0.85); abdominal circumference (<88 cm)

Table 2. Analysis the effects of intervention according to glycemic load groups. Metabolic profile.

Variables	All (n= 36)				moderate-elevate glycemic load (n=16)				low glycemic load (n=20)			
	baseline		after therapy		baseline		after therapy		baseline		after therapy	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
glucose (mg/dL)	98.91	± 10.35	94.50	± 7.26 [A]	98.20	± 9.12	93.06	± 6.34 [A]	99.45	± 11.39	95.65	± 7.88
insulin (uIU/mL)	13.52	± 5.94	11.51	± 5.08 [A]	13.34	± 5.86	11.24	± 4.24 [A]	13.67	± 6.14	11.73	± 5.76 [A]
HOMA-IR	3.30	± 1.81	2.68	± 1.17	3.13	± 1.76	2.58	± 0.98 [A]	3.43	± 1.88	2.75	± 1.32
total cholesterol (mg/dL)	194.72	± 34.31	178.50	± 35.78 [A]	196.44	± 35.74	184.94	± 36.64	193.35	± 33.99	173.35	± 35.16 [A]
HDL cholesterol (mg/dL)	52.66	± 13.03	50.66	± 10.62 [A]	52.63	± 13.05	49.88	± 9.56	52.68	± 13.38	51.32	± 11.65 [A]
non-HDL cholesterol (mg/dL)	140.67	± 30.10	129.14	± 29.62 [A]	143.81	± 32.24	135.06	± 32.41	138.15	± 28.87	124.40	± 27.08
LDL cholesterol (mg/dL)	114.50	± 27.85	104.53	± 28.24 [A]	115.06	± 28.81	108.25	± 30.93	114.05	± 27.80	101.55	± 26.32
VLDL cholesterol (mg/dL)	26.17	± 10.62	24.61	± 10.25	28.75	± 12.14	26.81	± 11.06	24.10	± 9.03	22.85	± 9.48
Tryglicerides (mg/dL)	131.28	± 52.34	123.31	± 51.52	143.13	± 60.51	134.00	± 55.28	121.80	± 44.07	114.75	± 47.99
AST (U/L)	16.60	± 11.28	15.91	± 7.38	16.00	± 3.29	15.31	± 4.84	17.11	± 15.18	16.42	± 9.09
ALT (U/L)	16.39	± 8.35	17.06	± 9.76	18.50	± 8.73	17.44	± 9.22	14.70	± 7.84	16.75	± 10.40
GGT (U/L)	21.28	± 12.70	21.25	± 11.57	21.44	± 13.54	19.63	± 9.89	21.15	± 12.34	22.55	± 12.86

HOMA-IR: Homeostatic Assessment Index; HDL: high density lipoprotein; LDL: low density lipoprotein; VLDL: very low-density lipoprotein; AST: Aspartate Aminotransferase; ALT: Alanine Aminotransferase; GGT: Gamma-glutamyltransferase

Generalized estimating equation (GEE) post hoc Sidak with Gama distribution. Statistical significance $p \leq 0.05$

[A]Statistical difference between baseline and after intervention

Reference Values: Insulin (2.5–30 uUI/mL); HOMA-IR (<2.7); Total cholesterol (<190 mg/dL); HDL: High Density Lipoprotein-Cholesterol (>40 mg/dL); LDL: Low Density Lipoprotein-Cholesterol (<100-130 mg/dL); VLDL: Very Low Density Lipoprotein-Cholesterol (10–50 mg/dL); TG: Triglycerides (<150 mg/dL); Alanine Aminotransferase (ALT) < 40 U/L; Aspartate Aminotransferase (AST) < 40 U/L; Gama Glutamil Transferase (GGT) >38 U/L

Table 3. Analysis the effects of intervention according to glycemic load groups. Dietary evaluation.

Variables	All (n= 36)				moderate-elevate glycemic load (n=16)				low glycemic load (n=20)			
	baseline		after therapy		baseline		after therapy		baseline		after therapy	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
calories intake (kcal/day)	2079.99	594.94	1422.68	338.42 [A]	2305.54	591.11	1440.54	314.80 [A]	1899.55	546.85	1408.38	363.66 [A]
carboydrates (g)	252.99	76.79	166.76	45.96 [A]	281.55	70.69	167.20	45.35 [A]	230.14	75.37	166.40	47.61 [A]
carboydrates (%)	50.25	6.89	47.60	7.38 [A]	51.91	5.84	47.47	7.25 [A]	48.92	7.50	47.70	7.67
fibers (g)	26.62	21.32	15.73	6.54 [A]	26.74	15.19	16.88	5.17 [A]	26.53	25.59	14.81	7.45
protein (g)	92.24	29.26	75.74	22.33 [A]	101.79	34.12	76.37	20.83 [A]	84.59	22.80	75.23	24.00
protein (%)	17.81	2.45	21.45	4.39 [A]	17.65	2.46	21.12	3.10 [A]	17.94	2.50	21.71	5.26 [A]
lipids (g)	77.40	26.40	50.31	16.52 [A]	81.06	26.72	50.90	13.69 [A]	74.46	26.46	49.84	18.82 [A]
lipids (%)	32.13	5.35	31.25	6.04	30.70	4.60	31.86	6.83	33.28	5.73	30.76	5.45
saturated fat	23.11	10.10	16.45	7.00 [A]	24.19	10.12	16.05	5.53 [A]	22.25	10.26	16.78	8.12 [A]
monounsaturated fat	19.85	10.36	13.62	5.59 [A]	19.22	10.95	14.16	4.50	20.35	10.12	13.19	6.41 [A]
polyunsaturated fat	18.70	35.91	7.21	3.12 [A]	14.46	6.05	8.21	3.04 [A]	22.09	48.16	6.40	3.02
cholesterol intake	380.82	194.93	345.52	169.23 [A]	403.77	218.74	347.62	146.50	362.46	177.26	343.85	189.23
Sodium (mg)	2381.18	959.92	1691.52	581.21 [A]	2685.95	1041.12	1817.79	669.84 [A]	2137.36	837.18	1590.50	493.83 [A]
folic acid (mcg)	154.60	93.70	144.09	80.10	203.69	99.25	159.69	62.16	115.33	68.88 [B]	131.60	91.65
Calcium (mg)	716.04	329.21	561.60	251.49 [A]	752.99	315.82	516.72	216.94 [A]	686.48	344.71	597.50	276.22
Iron (mg)	12.44	5.39	9.46	4.34 [A]	15.26	5.17	8.90	2.92 [A]	10.17	4.50 [B]	9.91	5.24
Zinc (mg)	9.49	5.27	8.04	3.07	12.13	5.37	8.30	2.75 [A]	7.37	4.21 [B]	7.82	3.36
Copper (mg)	1.24	1.00	0.94	0.65	1.72	0.91	0.91	0.44	0.85	0.90	0.96	0.79
Selenium (mcg)	37.66	22.71	41.52	36.10	46.74	27.74	46.19	42.26	30.40	14.75	37.77	30.93
glycemic index	499.94	138.59	510.54	137.75	540.08	168.12	541.15	145.63	467.82	103.08	486.05	129.57
glycemic load	78.49	33.13	54.55	20.59 [A]	108.10	27.10	58.94	20.52 [A]	54.80	10.61 [B]	51.03	20.47

Generalized estimating equation (GEE) post hoc Sidak with Gama distribution. Statistical significance $p \leq 0.05$

[A]Statistical difference between baseline and after intervention

[B]Statistical difference between the groups

Reference values: (DRI – RDA/AI*): carbohydrates (130g/d); fibers (25g/d*); protein (46g/d); lipids (ND); sodium (1500mg/d*); folic acid (400mcg/d); calcium (1000mg/d); iron (18mg/d); zinc (8mg/d); copper (0.9mg/d); selenium (55mcg/d).

Table 4. Analysis of intervention magnitude according to glycemic load groups. Deltas values of anthropometric and body composition parameters

Variables	All (n=36)		moderate-elevate glycemic load (n=16)		Low glycemic load (n=20)	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
body mass (kg)	-5.72	± 2.51	-6.48	± 2.61	-5.12	± 2.32
BMI (kg/m²)	-2.14	± 0.97	-2.41	± 1.09	-1.93	± 0.82
neck circumference (cm)	-1.40	± 1.02	-1.54	± 0.98	-1.29	± 1.06
waist circumference (cm)	-5.94	± 4.98	-6.64	± 3.05	-5.38	± 6.14
abdominal circumference (cm)	-5.11	± 4.28	-5.97	± 4.06	-4.42	± 4.43
hip circumference (cm)	-4.45	± 3.49	-5.25	± 3.47	-3.82	± 3.45
waist/hip ratio	-0.02	± 0.04	-0.02	± 0.03	-0.02	± 0.05
fat mass (%)	-2.70	± 2.19	-2.91	± 2.16	-2.54	± 2.26
free fat mass (kg)	-0.56	± 4.52	-1.53	± 1.60	0.22	± 5.85
RMR (kcal/day)	-8.22	± 130.94	-46.25	± 48.37	22.20	± 165.96

BMI: body mass index; RMR: resting metabolic rate
Generalized linear models (GzLM) post hoc Sidak with Gama distribution. Statistical significance $p \leq 0.05$

Table 5. Analysis of intervention magnitude according to glycemic load groups. Deltas values of metabolic profile

Variables	All (n=36)		moderate-elevate glycemic load (n=16)		low glycemic load (n=20)	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
glucose (mg/dL)	-4.69	± 8.09	-5.87	± 7.15	-3.80	± 8.80
insulin (uIU/mL)	-2.01	± 5.07	-2.09	± 2.68	-1.94	± 6.45
HOMA-IR	-0.62	± 1.54	-0.68	± 1.83	-0.55	± 1.12
total cholesterol (mg/dL)	-16.22	± 21.71	-11.50	± 16.44	-20.00	± 24.92
HDL cholesterol (mg/dL)	-2.00	± 6.14	-2.75	± 6.10	-1.37	± 6.26
non-HDL cholesterol (mg/dL)	-11.53	± 19.71	-8.75	± 19.92	-13.75	± 19.77
LDL cholesterol (mg/dL)	-9.97	± 18.54	-6.81	± 18.59	-12.50	± 18.59
VLDL cholesterol (mg/dL)	-1.56	± 7.98	-1.94	± 10.39	-1.25	± 5.66
Tryglicerides (mg/dL)	-7.97	± 39.75	-9.13	± 51.44	-7.05	± 28.62
AST (U/L)	-0.69	± 6.22	-0.69	± 5.61	-0.68	± 6.84
ALT (U/L)	0.67	± 8.51	-1.06	± 11.22	2.05	± 5.42
GGT (U/L)	-0.03	± 6.65	-1.81	± 7.74	1.40	± 5.42

HOMA-IR: Homeostatic Assessment Index; HDL: high density lipoprotein; LDL: low density lipoprotein; VLDL: very low-density lipoprotein; AST: Aspartate Aminotransferase; ALT: Alanine Aminotransferase; GGT: Gamma-glutamyltransferase
Generalized linear models (GzLM) post hoc Sidak with Gama distribution. Statistical significance $p \leq 0.05$

Table 6. Analysis of intervention magnitude according to glycemic load groups. Deltas values of dietary evaluation

Variables	All (n=36)		moderate-elevate glycemic load (n=16)		low glycemic load (n=20)	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
calories intake (kcal/day)	-657.31	± 525.28	-865.00	± 477.35	-491.16	± 512.84 [D]
carboydrates (g)	-86.23	± 80.46	-114.35	± 74.48	-63.74	± 79.67 [D]
carboydrates (%)	-2.65	± 7.06	-4.44	± 5.75	-1.22	± 7.80
fibers (g)	-10.89	± 21.83	-9.86	± 13.08	-11.71	± 27.23
protein (g)	-16.50	± 25.48	-25.42	± 24.53	-9.37	± 24.50 [D]
protein (%)	3.63	± 4.78	3.47	± 3.64	3.76	± 5.62
lipids (g)	-27.08	± 21.10	-30.16	± 22.93	-24.62	± 19.77
lipids (%)	-0.88	± 6.04	1.16	± 5.73	-2.52	± 5.91 [D]
saturated fat	-6.66	± 8.40	-8.15	± 9.33	-5.47	± 7.61
monounsaturated fat	-6.22	± 9.44	-5.06	± 10.62	-7.16	± 8.56
polyunsaturated fat	-11.49	± 35.26	-6.25	± 6.66	-15.69	± 47.05
cholesterol intake	-35.30	± 216.98	-56.15	± 202.41	-18.62	± 231.78
Sodium (mg)	-689.66	± 954.16	-868.16	± 1036.86	-546.85	± 883.20
folic acid (mcg)	-10.51	± 87.09	-43.99	± 74.60	16.28	± 88.77 [D]
Calcium (mg)	-154.44	± 302.86	-236.26	± 268.72	-88.98	± 319.08
Iron (mg)	-2.98	± 6.17	-6.36	± 4.38	-0.27	± 6.12 [D]
Zinc (mg)	-1.45	± 5.06	-3.83	± 5.53	0.46	± 3.79 [D]
Copper (mg)	-0.30	± 1.18	-0.81	± 0.83	0.11	± 1.27 [D]
Selenium (mcg)	3.85	± 36.87	-0.55	± 47.61	7.37	± 26.16
glycemic index	10.60	± 158.92	1.06	± 172.58	18.23	± 151.24
glycemic load	-23.94	± 35.37	-49.17	± 35.76	-3.77	± 18.19 [D]

Generalized linear models (GzLM) post hoc Sidak with Gama distribution. Statistical significance p≤ 0.05

Table 7. Association among Glycemic Load and nutritional components.

	Wald	Exp(B)	(95% CI)	p value
model 1				
carbohydrates (g)	13.441	1.003	(1.001 – 1.004)	**0.000**
carbohydrates (%)	0.041	1.002	(0.985 – 1.018)	0.840
model 2				
protein (g)	11.564	1.007	(1.003 – 1.011)	**0.001**
protein (%)	2.103	0.965	(0.920 – 1.013)	0.147
model 3				
lipids (g)	17.498	1.011	(1.006 – 1.017)	**0.000**
lipids (%)	10.907	0.955	(0.929 – 0.981)	0.001
model 4				
carbohydrates (g)	8.521	1.003	(1.001 – 1.005)	**0.004**
fibers (g)	2.317	.995	(0.989 – 1.001)	0.128
protein (g)	1.726	1.004	(0.998 – 1.011)	0.189
lipids (g)	0.733	0.997	(0.990 – 1.004)	0.392
model 5				
carbohydrates (g)	0.852	1.001	(0.999 – 1.004)	0.356
carbohydrates (%)	2.601	1.042	(0.991 – 1.094)	0.107
fibers (g)	4.007	0.994	(0.988 – 1.000)	**0.045**
protein (g)	0.005	1.000	(0.990 – 1.011)	0.946
protein (%)	0.808	1.045	(0.949 – 1.151)	0.369
lipids (g)	1.076	1.010	(0.991 – 1.028)	0.300
lipids (%)	.039	0.999	(0.991 – 1.007)	0.843

Regression Analysis evaluated by Generalized linear models (GzLM). In the models 1-3 the percentage of macronutrients were used as a covariate variable. Models 4-5: Multiple regression analysis. Values <1 for Exp(B) were adopted for negative association.

Figure 2. Prevalence of Metabolic Syndrome according to glycemic load groups. Metabolic Syndrome defined by International Diabetes Federation criteria (IDF)
*Statistical difference (p≤ 0.05)