

Does a Controlled Diet Improve Cellulite?

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Abstract: Several researchers have suggested that a targeted diet for reducing the adipose tissue may interfere with the severity of cellulite. Others emphasize that the diet composition seems to play a more relevant role than the calorie profile for weight loss and cellulite control.

Objective: The aim of this study was to evaluate the influence of a controlled diet on body composition and cellulite improvement in adult women.

Methods: Thirty two healthy women, aged from 25 to 40 were included. They received an orientation for a controlled diet to be followed for 3 months. Assessments were performed at the baseline and the end of the study which included four parameters: 1) Photonumeric cellulite severity scale; 2) Anthropometric measurements 3) Skin elasticity (Cutometer®) and 4) Collagen density or echogenicity and length of the dermis-hypodermis interface line (ultrasonography - DermaScan®). The data was compared with the Paired T-test, Wilcoxon and Pearson's correlation for statistical analyses.

Results: Only 14 completed the study. Although the scores of photonumeric scale reduced, there was no difference in the grade of cellulite severity. There were significant reductions in body measurement. The skin elasticity showed no significant change. On the other hand, the dermal density or echogenicity showed a significant increase in the right and left sides ($p = 0.05$ and $p = 0.005$, respectively); however, no difference was observed in the length of dermis-hypodermis line.

Conclusion: the controlled diet was effective for the reduction of weight and body composition, but despite the increase in dermal collagen density, no clinical effect on cellulite could be detected.

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Citation: Marques, N.C, Soares, J.L.M, Guadanhim, L.R.S, Sternberg, F.f.a, Picosse, F.R et al. (2016) Does a Controlled Diet Improve Cellulite?. International Journal of Nutrition - 2(1):25-37. <https://doi.org/10.14302/issn.2379-7835.ijn-16-986>

Key words: Diet, Cellulite, Carbohydrate, Fat Mass, Loss Weight

Received: Apr 07, 2016 **Accepted:** Jun 15, 2016 **Published :** Jul 22, 2017

Academic Editor: Guoxun Chen, The University of Tennessee

Introduction:

Cellulite is a localized skin surface irregularity that affects 85-98% of women after puberty.¹⁻² Alquier and Pavot first described it in 1920 as an unaesthetic alteration of skin surface secondary to traumatic, infectious and/or glandular stimuli.³ It is not considered a disease; therefore it does not affect life expectancy or involve risk of secondary diseases. However it may disturb physical, mental and social wellness, with psychosocial impacts.^{1,3-4} It is likely that the etiopathogenesis is multifactorial, and that the anatomical and structural changes in the connective and adipose tissues of women are considered the main factors.⁵⁻¹¹ Some authors have also cited alterations in microcirculation¹²⁻¹³, hormonal changes, genetic predisposition and nutritional factors as well.¹⁴⁻¹⁵

The therapies have common goals such as: induction of lipolysis in subcutaneous tissue; improvement of blood flow, skin elasticity and dermal thickness and reduction of the hypertroph connective tissue septa in the hypodermis. However, the effects are limited and temporary, and therefore the results are variable^{5,24,42,43}.

The role of a specific diet, which reduces the adipose tissue and thus the cellulite severity is controversial⁸. Some authors believe that the diet composition is more important than the calorie profile for weight loss.¹¹ Changes in the diet composition, like removing simple sugars, since they can increase the level of advanced glycation end products (AGEs) and a consequent collagen breakdown, could be beneficial.¹⁶

Another change could be a higher consumption of mono and polyunsaturated fatty acids, which is possibly correlated to the reduction of pro-inflammatory factors.¹⁷ As well as the increase in nutrients such as zinc and vitamins A, C and D because these may act in the epidermis, dermis and collagen fibers.¹⁸⁻¹⁹ And also, ingesting more fruit, vegetables and cereals that are

rich in terpenoids and polyphenols, due to its control of adipocyte differentiation.^{20,21} These also contain silicon, which contribute with the connective tissue metabolism.²²⁻²⁶

There are very few studies evaluating the relationship between dietary patterns and cellulite. However, most of them didn't use the adequate methodology or were inconclusive. Therefore our question was if the possible change in the dietary pattern would reduce the cellulite severity by reducing the subcutaneous fat and/or improving the dermal structure.

Material and Methods:

The participants were recruited in the Cosmetic Dermatology Unit of the Department of Dermatology at the Federal University of Sao Paulo (UNIFESP) after the UNIFESP Ethics Review Board approved. They signed the Consent Form and Photography authorization.

The study design was a therapeutic intervention, open, not randomized and evaluator blinded, including 32 healthy women; aged from 20 to 40. The inclusion criterion was: eutrophic and overweight (according to Body Mass Index - BMI), with visible cellulite on the buttocks, grades II or III, according to Nurnberger-Muller classification⁵. Exclusion criteria were: pregnancy or desire to become pregnant; currently nursing; history or clinical signs of venous insufficiency, arterial diseases, chronic diseases, mental disorders, and also have undergone any treatment for cellulite in the last 6 months, like gluteoplasty or liposuction in the areas with cellulite.

During their first visit, participants were asked to fill out a 24-hour diet recall for qualitative analysis of their dietary pattern. They were also asked about physical activity, oral contraceptive use and previous pregnancy. They received an oral and written

orientation for the controlled diet to be followed for 3 months.

The diet was based in the maintenance of a nutritional balance with a predominance of fresh food, aimed to increase the ingestion of antioxidants. The distribution of macronutrients comprised: 55-65 %, carbohydrate, 20-35% fat and 10-20%, protein. The original quantitative intake, that was assessed by the 24-hour recall was maintained. The difference was the food choices, with a prioritization of the nutritional quality and, thus, directing the participant to what was permitted and prohibited (**Figure 1**). The diet was characterized by less industrialized food, low content of saturated and trans fatty acids and low consumption of simple carbohydrates. The participants were advised to consume whole-grain foods, avoid sugar and candies, maintain high levels of animal and vegetable proteins, eat vegetables and legumes freely and completely avoid alcohol. They were also instructed to consume vegetable and red fruit juice once a day. Efficacy assessments were performed at the baseline and at the end of the study, except for the diet recall, which was calculated on the following four days: 01, 30, 60 and 90.

The quantitative analysis was performed by calculating the distribution of macronutrients in the total caloric value, polyunsaturated fatty acids and total fibers, using the Dietwin professional software (version 2979, 2014 / Brazil), which is considered an effective method to assess the amount of nutrients ingested.

The efficacy parameters included:

Photonumeric cellulite severity scale

At the end of the study, three independent observers (all dermatologists) conducted a blind evaluation of before and after through photos that were taken, using the photonumeric cellulite severity scale (PSSC).²⁷

To ensure photograph standardization, participants used similar disposable underwear. Photos were not taken during the first 4 days of menstruation, to avoid possible interference of liquid retention. The photos were taken in a dark room, with a black background and two points of light located at 0,7m from the ground, suspended by a tripod and at 1m from the participant. The camera (Canon EOS - Rebel XTi, USA) was set on a tripod and located at 2 m from the participant. They were asked to remain motionless and

Figure 1: Controlled diet composition

Food group	Controlled diet
Cereals	Eat only whole grains
Breads and Biscuits	Eat only whole grain breads, without sugar and hydrogenated fatty acids
Pasta	Not consume
Grains and beans	Consume with preparations low fat
Nuts	Consume without sugar and salt
Vegetables	Consume all colors
Tubers	Consume with preparations low fat Consume without cereals at the same time
Fruits	Consume all colors
Beverage	Consume tea and water, without sugar No consume alcoholic drinks
Sugar	No sugar added
Fat	Consume vegetable oils like olive oil
Meat and eggs	Consume with low fat preparations
Dairy products	Consume only yogurt, without sugar

relaxed with no contraction of the hip and lower limb muscles. A reference point was marked on the ground to stand by tagging the carpet which ensured standardization of the distances.

Anthropometric measurement

Circumferences of the waist, abdomen and hips were measured with a non-extensible measuring tape. The thickness of five skinfolds, at the right side of the body, with the participant standing, was taken (biceps, triceps, subscapular, abdominal and suprailiac).²⁸ Sums at baseline and day 90 were generated, which were later used as an indirect method to assess changes. Weight was measured using a simple electronic balance and the participant reported their height.

Body composition was assessed by bioimpedance (BIA 101 Quantum, RJL Systems Detroit, MI, USA), which is a validated non-invasive method.²⁹ It is a fast and accurate form to estimate lean mass and fat mass, and also has relatively low cost.³⁰ This was not performed during the menstruation period to avoid the interference of fluid retention.^{31,32}

Skin Elasticity

Skin elasticity was evaluated using a Cutometer[®] device (MPA 580, Courage & Khazaka, Cologne, Germany) on standardized points of gluteal region, and the biological elasticity (R7 value) was determined.

Collagen density and length of dermis-hypodermis interface line

A high-frequency (20 MHz) ultrasound (US) device (DermaScan[®] C USB, Cortex Technology ApS, Denmark) was used, which allows high resolution sectional skin images up to a depth of 3mm, that show both epidermis and dermis. From the images is possible to calculate the echogenicity, which correspond to the dermal extracellular matrix density³³, as well as the

length of the line between dermis and hypodermis (the longer the line, the greater is the protrusion of the hypodermis toward the deep dermis). The measurements were taken at the same points of gluteal region that was used for skin elasticity.

Statistical analysis

The data was compared with the Paired T-test, Wilcoxon and Pearson's correlation for statistical analyses, using a statistical program (GraphPad - Prism version 5 - USA). The test used was decided according to the normal curve, two-tailed. The values were considered significant for p value < 0.05.

Results:

Out of the 32 women who participated, only 14 completed the study. This represents a dropout rate of 56% (18/32). The main cause of dropout was non-adherence to the proposed diet (10 women). Other causes were: absence in the last assessment (7 women) and unexpected pregnancy (1 woman). Statistically there was no difference in the BMI at the baseline between the participants who finished the study (24, 5 ± 3 , 1 kg/m^2) and those who dropped out (28, 4 ± 6 , 8 kg/m^2), therefore the BMI was not a cause for the dropout.

For baseline analysis, the ITT (*intention to treat*) population ($n=32$) was considered. **Table 1** shows the baseline data, including participants' mean age, weight and BMI, pregnancy history and oral contraceptive use. **Table 2** comprises data for the participants' level of physical activity, showing that 44% reported a moderate or intense level and 16% reported light physical activity. They were instructed to maintain this practice throughout the study, avoiding the bias of a pattern change. The sedentaries (40%), were instructed to remain so until the end of the study.

Table 1. Mean age, weight, Body Mass Index (BMI); pregnancy history and oral contraceptive use at baseline (ITT population)

	n=32
Age (years)	32.2±5.0*
Weight (kg)	72.4±3.1*
BMI (kg/m ²)	26.7±0.9*
Nulliparous	(23/32) 71.9%
Oral contraceptive	(14/32) 43.8%

Note: *mean and standard deviation

Table 2. Level of physical activity (ITT population)

	n=32
Sedentary	(13/32) 40%
Light	(5/32) 16%
Moderate	(9/32) 28%
Intense	(5/32) 16%

The food consumption data recorded in the 24-hour diet recall at baseline showed that most participants consumed industrial products, foods with high glycemic index and rich in saturated fat, more than twice a day (**Table 3**).

Photonumeric cellulite severity scale

For data analysis, we considered the mean values attributed to cellulite severity on gluteal regions, by three independent observers, at baseline and day 90 by using the PP (per protocol) population. It was observed that the total scores reduced, but the results were not significant (right side, $p=0.3033$; left side,

Table 3. Food groups in the 24-hour diet recall of the participants at baseline (ITT population)

n=32	<1x /day	1-2x /day	>2x /day
Industrialized food	10%	31%	59%
High glycemic food	10%	50%	40%
Foods with saturated or trans fat	6%	31%	63%
Vegetables	28%	38%	34%

$p=0.3955$). **Figure 2** shows the cellulite clinical aspect in the gluteal region of one participant at baseline and day 90, with no noticeable difference.

Anthropometric data and bioimpedance

Table 4 presents the mean and standard deviation of the anthropometric measurements and the percentage of lean mass and fat mass obtained by bioimpedance. There were significant reductions in body measurements, such as: weight, BMI, skinfold sum, waist and abdomen circumferences, percentage of lean and fat mass. These data demonstrated the effectiveness of the controlled diet for weight loss and reduction in body measurements.

Skin Elasticity

The skin elasticity showed no significant change (right side, $p=0.4409$; left side, $p=0.3174$) when compared to the mean of the measures at baseline and day 90 (PP population).

Results from the ultrasonography

Table 5 presents the mean of the measures for dermal echogenicity and the length of the dermis-hypodermis interface line, obtained by the US images. The dermal density showed a significant increase for both sides (right, $p=0.02$; left, $p=0.005$). However, the length of dermis-hypodermis interface line showed no significant change. **Figure 3** shows the US images of one participant



Figure 2. Cellulite clinical aspect in the gluteal region of one participant at baseline and the end of the intervention

Table 4. Mean and standard deviation of anthropometric measurements and percentage of bioimpedance data at baseline and end of intervention (PP population)

n=14	baseline	day 90	p - value
Weight (kg)	66.8±11.5	63.0±11.6*	0.0001*
BMI (kg/m²)	24.5±3.1	23.1±3.1*	0.0001*
Σ skinfold (mm)	80.4±24.3	64.4±24.3*	0.0004*
Waist (cm)	75.5±8.5	71.5±7.6*	<0.0001*
Abdominal (cm)	85.6±9.3	83.3±7.5*	0.02*
FM (%)	29.3±5.4	27.1±4.7	0.004*
LM (%)	68.1±7.9	72.3±4.9	0.015*
EW (%)	46.5±2.6	46.1±2.6	0.36

Note: * p<0,05 (Paired T-test) - significant values; BMI - Body Mass Index; Σ skinfold - sum of skinfold thickness of: biceps, triceps, subscapular, suprailiac, abdominal; FM= Fat Mass; LM= Lean Mass; EW= Extracelular Water

Table 5: Mean and standard deviation of the measures for dermal echogenicity and the length of the dermis-hypodermis interface line for gluteal regions at baseline and end of intervention (PP population)

n=14	Dermal echogenicity			Lenght of the dermis-hypodermis interface line		
	Baseline	day 90	p-value	baseline	day 90	p-value
Right	0.23±0.13	0.30±0.14	0.05*	12.61±0.53	12.59±0.49	0.44
Left	0.21±0.11	0.31±0.09	0.005*	12.59±0.53	12.55±0.40	0.73

Note: * p<0,05 (Wilcoxon) - significant values

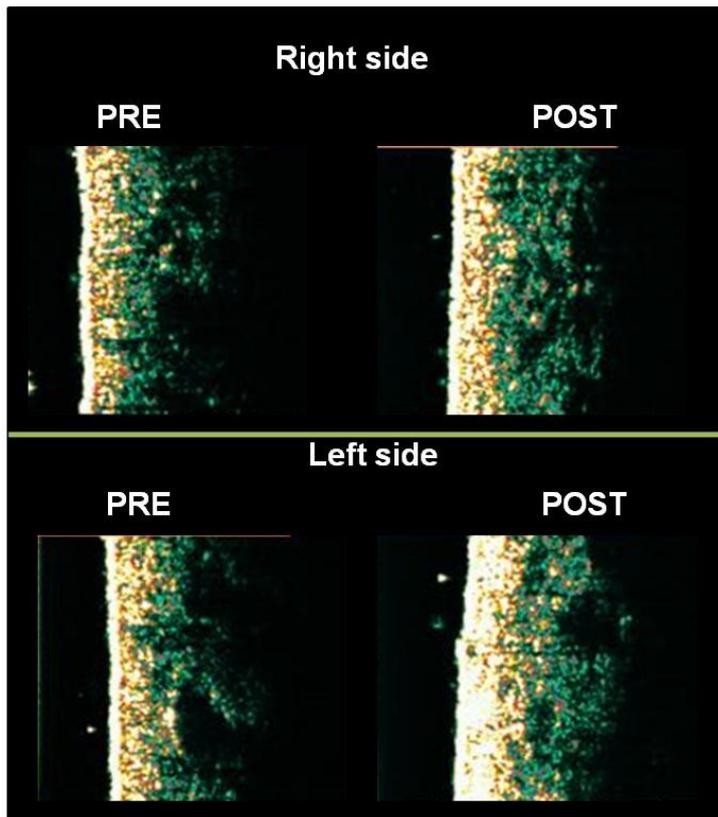


Figure 3. High frequency US images of one participant, showing an increase in dermal echogenicity in gluteal regions by the comparison between baseline and end of intervention

Dietary consumption

The quantitative calculation demonstrated that the participants followed the controlled diet throughout the intervention period. By observing the macronutrient distribution, it is possible to verify that the participants consumed an average of 35% lipids, 47% carbohydrates and 18% protein from the Total Caloric Values (TCV). **Figure 4** shows a comparison between controlled diet and normal diet. There was a higher consumption of total lipids, polyunsaturated fatty acids and fiber in the controlled diet, but without statistical significance. Positive correlations were observed between weight loss and lipids consumption ($r=0.764$; $p=0.001$) and a negative correlation between weight loss and carbohydrate consumption ($r=-0.787$; $p=0.007$).

Discussion

Cellulite control depends on the association of various therapeutic interventions, due to its multifactorial etiology, despite the unclear mechanisms. Invasive and non-invasive treatments are based on existing theories about its pathogenesis, as well as trying to mitigate supposed aggravating factors such as unproven changes in the dermis and hypodermis - microcirculation and chronic inflammation.^{34,35} In this study, we opted for a non-invasive approach by changing the dietary pattern.

The occurrence of a 56% dropout rate illustrates the poor adherence of participants to a restricted diet. Dropouts in clinical studies about cellulite are frequent, due to the absence of visible short-term results and the participant's lack of interest in maintaining the therapeutic proposals.^{27, 36} Following a controlled diet during medium and long term, even though providing many benefits, is difficult to maintain considering individual habits and food preferences.³⁷⁻³⁹

The weight and BMI at baseline, as well as the level of physical activity corroborate with the assumption that women who are bothered by cellulite and seek treatment, generally with high expectations, are those who possess healthier life habits and higher aesthetic concern³⁷⁻³⁹, but, whose food habits at baseline were characterized by large amounts of high glycemic food.

Although there is no consistent evidence on which food groups affect cellulite, the analysis of the diet recall before the intervention showed that most participants were used to eating industrialized food, with high glycemic index and rich in trans fatty acids. It is possible that these food groups can be associated with cellulite. And the lack of vitamins and minerals, which act as antioxidants, may also have some impact in the dermis structure, as was pointed out by several authors.^{18, 40-46}

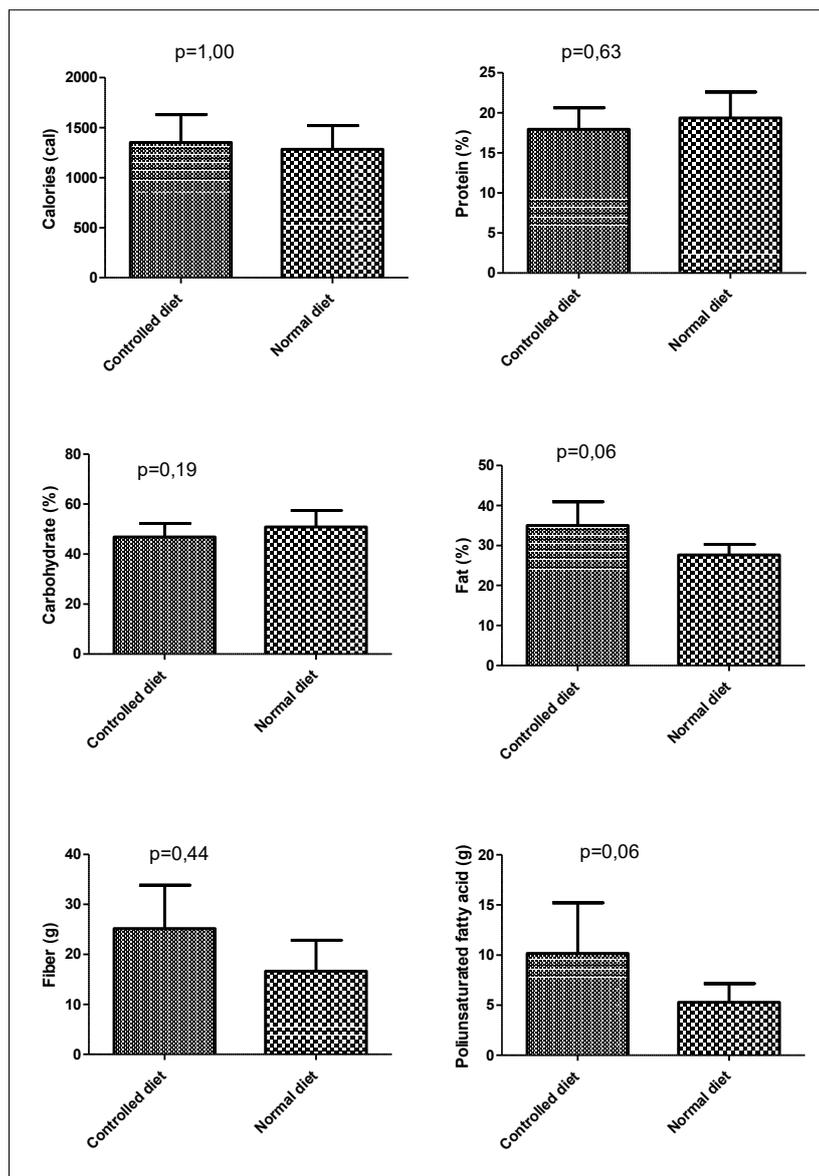


Figure 4. Comparison of controlled diet and normal diet according to the average of nutritional intake during the intervention.

Note: not significant values (Wilcoxon)

presence of foods rich in saturated and trans fatty acids seems to increase fat deposition, with weight gain and development of inflammatory processes.⁴⁹ A study conducted in 2013 compared three diets with the same caloric intake and different profiles of saturated fat (6%, 12%, 24%) for 16 weeks in an animal model (rat). It was observed that the diet with 12% saturated fat increased adiposity, inflammatory markers and promoted metabolic dysfunction; the diet with 24% saturated fat displayed an increase in insulin resistance and a higher ratio of triglycerides and LDL-cholesterol which are known as cardiovascular risk factors.⁵⁰

The controlled diet resulted in weight loss, reduction in the skinfolds sum and percentage of fat. It was observed, a visible change in body composition and an increase in dermal echogenicity, possibly by a positive effect in collagen density and organization, in the areas with cellulite⁵¹⁻⁵⁵. However, as weight loss is distributed throughout the body, there is no guarantee that the fat in areas affected by cellulite was also reduced.

Additionally, it is not possible to assert that this result can always cause improvement in the dimpled appearance of the skin surface, as previously described in the literature.⁵⁶

The photography analysis demonstrated no significant reduction in the scores. But it has been suggested that reducing adipose tissue, independent of body obesity, can improve cellulite severity^{7,8} in healthy persons. It depends greatly on the quality and quantity of their daily diet.

Some studies have discussed that the consumption of foods with high glycemic index can accelerate the collagen tissue glycation.^{47,48} The

However, this study, despite its limitations, suggests that weight loss by a controlled diet may provide structural dermal changes..

The presence of macronutrients in the controlled diet, seems to have had a large contribution to weight loss, as the caloric food intake was maintained.⁵⁷ The controlled diet included a higher ingestion of fat when compared to the normal diet. It is important to note that this corresponded to a greater consumption of

polyunsaturated fatty acids, which may have contributed to the weight loss.

A negative correlation was found between the consumption of carbohydrates and weight loss. It is probable that the participants experienced weight loss due to the limitation of high glycemic index of processed foods, such as pasta, sweets and desserts with added sugar or other sweeteners.. This result is consistent with the findings of another study that demonstrated the greater effectiveness of a low glycemic index diet for weight loss as compared with a low fat and higher glycemic index.⁵⁸ In addition, to maintain weight after the initial loss, a low glycemic food load appears to be more effective, due to the positive correlation between low glycemic index and slower digestion, enhancing the intake of proteins and fats as they are related to satiety.⁵⁹

In the present study, protein intake was maintained within normal limits according to DRI,⁵⁷ that is, the controlled diet was normoproteic. Clifton et al in a similar intervention did not demonstrate significant difference in weight loss among participants who followed a high proteic diet compared to a standard diet, which is in accordance to our findings.⁶⁰ However, the influence of protein intake on weight loss remains controversial, since other investigators have reported that high proteic diets contribute to satiety and consequent reduction in food consumption.⁶¹

Considering only diet and its influence on cellulite, a study showed that a high proteic diet combined with reduced carbohydrate consumption, showed better response in reducing cellulite severity. The participants followed a proteic diet also experienced weight loss. But this diet was also rich in fat, which was not discussed.⁶²

Our study demonstrated that weight loss was obtained with a diet rich in fat consumption, normal range of reduced carbohydrates and changes oriented

only in relation to type of foods. There was a significant increase in dermal echogenicity in gluteal regions that could be related to an improvement in collagen tissue. We do not have an explanation about the mechanism involved. It is possible that a reduction in collagen glycation and inflammation in the dermis and adipose tissue may have occurred, despite the short time of the intervention. The study duration was chosen so that the results could be compared to the scarce literature available^[63-70].

The results for skin elasticity, contrary to our expectation, were not significant. This aspect may be related to weight loss, as it leads to metabolic abnormalities that can compromise skin elasticity.² Other authors have suggested that weight loss may be associated with changes in the dermis, the reduction of skin elasticity and negative interference in cellulite too.^{71,72} Non-invasive interventions for cellulite, in limited period, are targeted to reduce subcutaneous fat and/or edema and not to improve skin elasticity.

The majority of the results in this study was non-significant. It is important to highlight the complexity in assessing cellulite severity, the disparity between researchers' and participants' opinion and, above all, the challenge to control this common and uncomfortable disorder.

Conclusion:

This study demonstrated the efficacy of a controlled diet in reducing weight and body composition, accompanied by a possible increase in collagen density, despite no effect in cellulite clinical appearance.

We believe that further studies on genes related to obesity, as well as studies on cellulite pathogenesis, epidemiology, genetic predisposition, triggers, aggravating conditions, cellular and molecular mechanisms would be useful to direct the therapy. It is important to combine a healthy lifestyle, including diet

and exercises, with long-term non-invasive or invasive therapeutic interventions. The successful treatment remains distant. Unfortunately as cellulite continues to bother women, many of them become hostages of costly treatment proposals, most of which, without a solid scientific basis.

Acknowledgements: for the financial support from Foundation for the Support of Research of the State of Sao Paulo (FAPESP) #2011/51633-8

Conflict of interest: the authors declare no conflict of interest

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