Effect of weight and body composition changes on waist measurement of severely obese women receiving carbohydrate-restricted diet

Efeito da alteração de peso e composição corporal sobre medidas abdominais de mulheres obesas graves, recebendo dieta com restrição de carboidratos

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A B S T R A C T

Objective

To evaluate the effect of weight and body composition changes on waist measurement of severely obese women receiving a low-carbohydrate diet for a short-term.

Methods

Nineteen severely obese women divided into an intervention and a control group received a low-carbohydrate diet and a conventional diet, respectively, both with 1,200kcal, for seven days. Anthropometric measurements such as weight, body mass index, arm circumference, waist circumference (at the navel), two proposed measurements of waist circumference (waist circumference 1, 10cm above the navel; and waist circumference 2, 20cm above the navel), hip circumference; and body composition (lean mass and fat mass) were performed at baseline and end of the study.

Results

There was significant reduction of all variables in the intervention group ($p<0.01$), but the control group had no change in waist circumference ($p=0.06$) and hip circumference ($p=0.36$). Patients of the intervention group

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presented greater weight loss (4.4kg, *p*<0.01) and reduction of body mass index, waist circumference, waist circumference 1, waist circumference 2 (*p*<0.01), and fat mass (*p*=0.04) than the control group.

Conclusion

The weight loss and body composition changes were greater in the low-carbohydrate group than in the conventional-diet group, and they had a greater impact on waist measurements. The proposed measurements (waist circumference 1 and waist circumference 2) were sensitive to weight reduction in both groups.

Indexing terms: Abnominal circumference. Body composition. Diet, carbohydrate-restricted. Weight loss.

R E S U M O

Objetivo

Avaliar o efeito da alteração de peso e da composição corporal em medidas abdominais de mulheres obesas graves em dieta restrita em carboidratos por curto período.

Métodos

Dezenove mulheres obesas graves, divididas em grupo-intervenção (n=10) e grupo-controle (n=9), receberam durante sete dias, respectivamente, dieta restrita em carboidratos e dieta convencional, com 1 200kcal. As avaliações antropométricas - peso, índice de massa corporal, circunferência do braço, circunferência abdominal (na cicatriz umbilical), incluindo dois novos pontos propostos de medida de circunferência abdominal (circunferência abdominal 1, 10cm acima da circunferência abdominal; e circunferência abdominal 2, 20cm acima da circunferência abdominal), e circunferência do quadril - e as de composição corporal (massa magra e massa gorda) foram realizadas no início e no final do estudo.

Resultados

Houve redução significativa de todas as medidas analisadas no grupo-intervenção (p<0,01), e o grupo-controle não teve alteração em circunferência abdominal (p=0,06) e circunferência do quadril (p=0,36). As pacientes do grupo-intervenção apresentaram maior redução de peso (4,4kg, p<0,01), índice de massa corporal, circunferência abdominal, circunferência abdominal 1 e circunferência abdominal 2 (p<0,01), além de redução da massa gorda (p=0,04), quando comparadas às pacientes do grupo-controle.

Conclusão

A redução de peso, a mudança na composição corporal e o impacto nas medidas abdominais foram maiores com dieta com restrição de carboidratos do que com dieta convencional. As medidas propostas (circunferência abdominal 1 e circunferência abdominal 2) foram sensíveis à redução do peso em ambos os grupos.

Termos de indexação: *Circunferência abdominal. Composição corporal. Dieta com restrição de carboidratos. Perda de peso.*

I N T R O D U C T I O N

Severe or grade III obesity is caused by excessive accumulation of adipose tissue and carries a very high risk of comorbidity. Many methods are used for measuring body composition, such as Bioelectrical Impedance Analysis (BIA) and anthropometric assessment. The latter includes weight, height, Body Mass Index (BMI), Waist Circumference (WC), Hip Circumference (HC), and waist-to-hip ratio[1].

Anthropometric measurements are easy and inexpensive ways to assess nutritional status, but they have some problems such as the errors related to the use of the technique that may stem from interpersonal variation or difficulties related to individuals' physical characteristics[2].

Although body mass index is one of the most common nutritional assessment methods, its limitations include not assessing the percentage of body fat and cut-off points unadjusted for gender and ethnicity[3,4]. However, when associated with other methods, it is an effective means of nutritional status assessment.

Waist circumference is more sensitive than BMI for assessing excess visceral adiposity[5]. High

WC is also associated with chronic Non-Communicable Diseases (NCD), such as hypertension and high serum lipids[6], conditions aggravated by the accumulation of abdominal fat[2,7]. The increased of WC measurement prevalence has been higher[8,9] than that of BMI, showing its importance and the need of measuring it accurately.

One of the main challenges regarding body measurements is the determination of the WC of severely obese patients[10] whose excess abdominal fat turns the abdomen into an apron because of gravity. This change in abdominal shape impairs or even prevents measuring waist circumference as usual, which requires finding the midpoint between the last rib and iliac crest[11,12]. The development of sensitive anthropometric measurements for assessing weight changes and distribution of body fat is important for making the nutritional diagnosis and monitoring of obese patients, especially those with severe obesity that often prevent conventional measurement techniques.

According to Fett *et al.*[13], BIA helps the nutritional assessment by determining the body composition; they compared this technique with anthropometric assessments and the association of these measurements with blood markers, such as cholesterol and fractions, triglycerides, glucose, and uric acid in normal weight women and women with different obesity grades. These authors found that anthropometric assessments are sensitive enough for assessing body composition and that the percentage of body fat correlates well with biochemical markers.

Various types of diet are used for treating obesity. A low-carbohydrate diet that restricts carbohydrate intake to less than 20% of the total energy has been widely used for reducing weight and abdominal fat[14,15]. A study with obese women receiving three different diets (low-carbohydrate and high fat diet; high protein diet; and high carbohydrate and fiber diet - control diet) found that the weight loss and waist circumference reduction were higher in women consuming the low-carbohydrate diet after a 24-week intervention[16]. A similar result was showed in another study: a very low-carbohydrate diet followed by obese women resulted in greater fat and lean body mass reduction after three and six months, respectively, than one low fat[17].

The evaluation of body measurements and body composition are very important for identifying obesity and body changes due to dietary interventions. These identify excess body fat, its distribution, especially abdominal obesity, strongly related with the onset of cardiovascular diseases[2,3,18] and allow one to know the effects of diet composition on body changes. Therefore, the objective of this study was to assess the effect of weight and body composition changes on the abdominal measurements of severely obese women receiving a short-term low carbohydrate diet.

METHODS

Twenty obese females with a BMI >40kg/m² aged 20 to 50 years were selected for the study and hospitalized at the *Hospital da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo* (HCFMRP-USP). Exclusion criteria were diabetes *Mellitus*, use of diuretics, chronic renal failure, chronic liver failure, obesity caused by endocrine diseases, eating disorders, and severe psychiatric diseases, including alcohol and drug abuse, neoplasms, and active systemic inflammatory or infectious diseases[19]. Indeed, patients taking metformin were asked to discontinue it.

The participants signed an Informed Consent Form and were divided into two groups: the intervention group, which received the hypocaloric, low-carbohydrate diet, and the control group, which received a conventional hypocaloric diet.

This study was approved by the Research Ethics Committee of HCFMRP-USP (Protocol number 2937/2007) and it is a continuation of a greater study on severe obesity and low-carbohydrate diet[20].

Both groups received the same amount of energy (1,200kcal). However, the macronutrient composition of the diets was different. The intervention group received a diet containing 45g of carbohydrates (15%), 105g of proteins (35%), and 67g of fat (50%). The control group received a diet with 171g of carbohydrates (54%), 74g of proteins (23%), and 32g of fat (23%). Both were administered for seven days and fractioned into six meals per day.

The anthropometric and body composition measurements were evaluated at baseline (before starting the diet) and on the day 8 (after seven days of dieting). Weight was determined by an electronic scale (Filizola ID-1500) with an accuracy of 200g and capacity of 300kg and BMI was calculated. Arm, abdominal, and HC were measured using an inelastic tape measure (200cm). Arm Circumference (AC) was measured at the midpoint between the acromion and olecranon. Abdominal circumference was measured at three points: at the navel, a location used commonly by some services because of the inability to measure at the conventional point[11], the midpoint between the last rib and iliac crest, and two new proposed points: 10cm above the navel (WC1), and 20cm above the navel (WC2). HC was obtained at the widest point between the hip and buttock.

Body composition was assessed by BIA, used for estimating Lean Mass (LM) and Fat Mass (FM). BIA measures resistance in ohms, used in the formula[21] for calculating the LM and FM of obese individuals. The body composition was evaluated after an overnight fast using the device Biodynamics BIA 450.

The data were tabulated in an Excel spreadsheet and analyzed by the statistical software SAS® 9.0. A linear mixed effect model (random and fixed) was used for comparing the baseline and end-of-study variables, and Analysis of Variance (Anova) for comparing the differences between groups[22,23]. The results were presented as means ± standard deviation. The significance level was set at 5% ($p < 0.05$).

RESULTS

Twenty individuals were selected for this study but only nineteen completed the study. One person from the control group was excluded for not following the study protocol. The study sample was considered homogeneous regarding the anthropometric and body composition measurements (Table 1). The mean age was also similar between the groups: 35±8 years in the intervention group and 32±8 years in the control group.

Table 1. Baseline anthropometric and body composition assessment of the groups. *Ribeirão Preto* (SP), Brazil, 2007-2008.

Variables	Intervention group (n=10)		Control group (n=9)		p-value
	Mean	SD	Mean	SD	
Weight (kg)	141.9	26.6	135.8	14.8	0.52
BMI (kg/m²)	54.4	9.6	51.2	4.7	0.34
AC (cm)	45.8	4.3	46.9	3.5	0.55
WC (cm)	139.4	15.1	135.6	10.6	0.60
WC1 (cm)	131.5	13.6	128.5	11.4	0.58
WC2 (cm)	123.5	12.3	121.8	12.5	0.76
HC (cm)	152.7	20.3	143.8	5.6	0.19
LM (kg)	67.1	9.4	65.6	6.1	0.67
FM (kg)	74.9	17.7	70.3	9.1	0.45

Note: Values expressed as Mean ± Standard Deviation (SD); There was no statistically significant difference.
BMI: Body Mass Index; AC: Arm Circumference; WC: Waist Circumference; WC1: Waist Circumference 10cm above the navel; WC2: Waist Circumference 20cm above the navel; HC: Hip Circumference; LM: Lean Mass; FM: Fat Mass.

At the end of the study, the patients in the intervention group (n=10) presented significant losses for all anthropometric and body composition measurements (Table 2). On the other hand, the WC and HC of the patients in the control group did not decrease significantly (n=9), but the other parameters did (Table 3). Obese women with low-carbohydrate diet showed greater weight loss and waist circumference (WC, WC1 and WC2) and fat mass reduction than obese women following conventional diet (Table 4).

DISCUSSION

The use of two proposed measurements for determining waist circumference associated with the circumference at the navel was a strategy that evaluated the effect of diet on shape and body composition changes on abdomen. The conventional technique to verify waist circumference does not apply in patients with severe obesity due to large amount of fat in the abdomen. The control group experienced significant WC1 and WC2 losses, but not WC. The

Table 2. Anthropometric and body composition assessment of the intervention group during one week. *Ribeirão Preto* (SP), Brazil, 2007-2008.

Variables	Intervention group (n=10)				
	Day 1		Day 8		p-value
	Mean	SD	Mean	SD	
Weight (kg)	141.9	26.6	137.5	26.2*	<0.01
BMI (kg/m²)	54.4	9.6	52.6	9.4*	<0.01
AC (cm)	45.8	4.3	45.1	4.4*	<0.01
WC (cm)	139.4	15.1	134.8	13.5*	<0.01
WC1 (cm)	131.5	13.6	128.4	14.0*	<0.01
WC2 (cm)	123.5	12.3	120.6	12.2*	<0.01
HC (cm)	152.7	20.3	150.2	20.2*	<0.01
LM (kg)	67.1	9.4	65.4	9.3*	<0.01
FM (kg)	74.9	17.7	72.1	17.3*	<0.01

Note: Values expressed as Mean ± Standard Deviation (SD). *Statistically significant difference.

BMI: Body Mass Index; AC: Arm Circumference; WC: Waist Circumference; WC1: Waist Circumference 10cm above the navel; WC2: Waist Circumference 20cm above the navel; HC: Hip Circumference; LM: Lean Mass; FM: Fat Mass.

Table 3. Anthropometric and body composition assessment of the control group during one week. *Ribeirão Preto* (SP), Brazil, 2007-2008.

Variables	Control group (n=9)				
	Day 1		Day 8		p-value
	Mean	SD	Mean	SD	
Weight (kg)	135.8	14.8	133.3	14.5*	0.01
BMI (kg/m²)	51.2	4.7	50.2	4.6*	0.01
AC (cm)	46.9	3.5	46.4	3.4*	<0.01
WC (cm)	135.6	10.6	135.2	10.4	0.06
WC1 (cm)	128.5	11.4	127.2	10.9*	<0.01
WC2 (cm)	121.8	12.5	120.7	11.9*	<0.01
HC (cm)	143.8	5.6	143.2	5.8	0.36
LM (kg)	65.6	6.1	64.7	6.1*	<0.01
FM (kg)	70.3	9.1	68.5	8.8*	<0.01

Note: Values expressed as Mean ± Standard Deviation (SD). *Statistically significant difference.

BMI: Body Mass Index; AC: Arm Circumference; WC: Waist Circumference; WC1: Waist Circumference 10cm above the navel; WC2: Waist Circumference 20cm above the navel; HC: Hip Circumference; LM: Lean Mass; FM: Fat Mass.

Table 4. Comparison of the mean reduction in the anthropometric and body composition measurements of the intervention and control groups after one week. *Ribeirão Preto* (SP), Brazil, 2007-2008.

Variables	Intervention group (n=10)		Control group (n=9)		p-value
	Mean	SD	Mean	SD	
Weight (kg)	4.4	2.2	2.6	0.7*	<0.01
BMI (kg/m²)	1.7	0.8	1.0	0.3*	<0.01
AC (cm)	0.7	0.5	0.5	0.5	0.27
WC (cm)	4.6	2.6	1.3	1.1*	<0.01
WC1 (cm)	3.1	1.6	1.3	0.9*	<0.01
WC2 (cm)	2.9	1.3	1.1*	1.0*	<0.01
HC (cm)	2.5	2.9	0.6	0.7	0.08
LM (kg)	1.7	1.0	0.9	0.4	0.05
FM (kg)	2.8	1.4	1.7	0.5*	0.04

Note: Values expressed as Mean ± Standard Deviation (SD). *Statistically significant difference.

BMI: Body Mass Index; AC: Arm Circumference; WC: Waist Circumference; WC1: Waist Circumference 10cm above the navel; WC2: Waist Circumference 20cm above the navel; HC: Hip Circumference; LM: Lean Mass; FM: Fat Mass.

intervention group experienced significant losses in all three measurements.

When the groups are compared, all indicators changed, except for arm and hip circumferences. Regarding anthropometric measurements, abdominal circumferences were more sensitive to dietary changes, despite the short-term intervention. The obese women with low-carbohydrate diet had greater reduction of waist circumference when compared to obese women with conventional diet. Nevertheless, these values were still much higher than those recommended by the World Health Organization (WHO)[24]. Verweij *et al.*[25] discuss the errors associated with abdominal circumference measurements, showing that the changes between them may be clinically significant. However, additional abdominal measurements, such as those performed by the present study (WC1 and WC2), may attenuate the errors by increasing the accuracy of the abdominal measurements.

The significant reduction in the WC measurements of the intervention group may suggest an improvement in the metabolic profile, as demonstrated by Laaksonen *et al.*[26], who studied patients with the metabolic syndrome following a hypocaloric diet during nine weeks and maintaining the weight for one year; they found that weight loss reduced body fat and waist circumference, which correlated with higher insulin sensitivity. According to Ravensbergen *et al.*[7] and Martins & Marinho[27], WC is significantly associated with hypertension and hypercholesterolemia.

Shai *et al.*[28] compared the consumption of a low-carbohydrate, a low-fat, or the Mediterranean diet by obese grade I followed by two years. Even though all groups lost waist circumference, the intergroup differences were not significant. However, the low-carbohydrate diet promoted a waist circumference reduction of 3.8cm, similar to the value found by the present study with a low-carbohydrate diet, which was of 4.6cm (WC), 3.1cm (WC1), and 2.9cm (WC2).

As observed by the control group, the proposed measurements for determining waist circumference (WC1, WC2) were sensitive to weight loss during the study period, showing that these measurements are effective and may be used, along with WC, to follow the body changes in severely obese individuals.

The obese women with low-carbohydrate diet experienced a greater weight loss than the obese women with conventional diet during the intervention period of one week. These data were corroborated by the results of many studies but with longer intervention periods, such as Samaha

et al.[29] who compared a low-carbohydrate diet (<30g/day) with a conventional hypocaloric diet (caloric restriction of 500kcal/day) in 132 severely obese individuals (BMI ≥35kg/m²). The authors found that, after six months, the low-carbohydrate group had a weight loss of 5.7kg, and the conventional-diet group reduced 1.8kg of body weight[28,30].

The Fat Mass and Lean Mass of both groups decreased significantly after one week. However, only the FM loss differed significantly between the groups, with the intervention group experiencing a greater loss than control group. The LM loss of the two groups did not differ, perhaps because of the short-term intervention. The reductions seen in the FM values for the intervention and control groups were, respectively, 2.7kg and 1.7kg, while for the LM they were 1.9kg and 0.9kg. These results are higher than those found by a review[31] that analyzed the effects of protein and carbohydrate intake on body composition in patients with hypocaloric diets, finding that a low-carbohydrate diet reduced fat mass by 1.8kg and lean mass by 0.3kg in studies up to 12 weeks.

Another study[14] compared a low-carbohydrate diet with a low-fat diet and their effects on the body composition of obese women and found that the low-carbohydrate group experienced a greater FM loss (4.7kg) and LM loss (5.9kg) at three months, and a reduction of 5.1kg and 5.8kg, respectively, at six months.

Dietary changes have an important impact on body composition and body measurements, suggesting the need of improving anthropometric techniques and technologies to assess the body compartments.

CONCLUSION

The proposed abdominal measurements (WC1 and WC2) for severely obese women effectively reflected the effects of a low-carbohydrate diet, especially in abdominal obesity

measurements, since they increase the accuracy of abdominal measurement. Weight loss and body composition change were greater in obese women with low-carbohydrate than in obese women with conventional diet and the low-carbohydrate diet had a greater impact on the abdomen of the obese women. Associated with other anthropometric and body composition indicators, the proposed measurements improve nutritional assessment. The validation of these new tools in future studies will allow their use in the professional routine.

CONTRIBUTORS

AT TRIFFONI-MELO and RW GARCIA DIEZ were responsible for the design, data collection, literature review, analysis and writing of the manuscript. RCL SANTOS collaborated in the study design, data collection, analysis and writing of the manuscript. RW DIEZ-GARCIA supervised this study. All authors were responsible for the critical review of the manuscript.

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