Trends in Biomedical Research

Research Article ISSN: 2632-0509

Therapeutic effectiveness of moderate energy restriction in obese Tunisian women

Bouchoucha Mongia[1,2], Bouchoucha Rim[2,3], Bellali Hédia[2,4*], Akrout Mouna[1,2], Kallel Amani[5], Jemaa Riadh[5], Feki Moncef[5], Slimane Hédia[3] and Ben Mansour Abderraouf[2,6]

[1]Department of Nutrition, Ecole Supérieure des Sciences et Techniques de la Santé de Tunis, Université de Tunis El Manar, Tunis, Tunisia

[2]UR 14SP01, Research Unit "Analysis of the effects of environmental and climate changes on health", Department of Epidemiology and Statistics, A. Mami Hospital, Ariana, Tunisia

[3]Service of Endocrinology-Diabetology, La Rabta Hospital, Jebbari, 1007 Tunis, Tunisia

[4]Department of Epidemiology and Public Health, Faculty of Medicine of Tunis, Tunis-El Manar University,Tunis, Tunisia

[5]Laboratory of Biochemistry, Faculty of Medicine of Tunis, Tunis El Manar University, La Rabta Hospital, Jebbari, 1007 Tunis, Tunisia

[6]Department of Physiology, Faculty of Medicine of Tunis, Tunis-El Manar University, Tunis, Tunisia

Abstract

Objective: To assess the effectiveness of moderate energy restriction for 6 months with reinforcement of household activities, in Tunisian obese women.

Design: We conducted a nutritional intervention for 6 months.

Participants: We included consecutively 75 volunteer obese women in the "Obesity Unit", Endocrinology Service, La Rabta Hospital, Tunisia; in January 2013.

Intervention(s): We prescribed a diet of 1600 Kcal/day; providing 57% of energy as carbohydrate, 30% as fat, and 13% as protein. We advised the reinforcement of the domestic housework activities.

Main outcome measure(s): Demographics, lifestyle behaviors, anthropometrics, biologic parameters and dietary intake were assessed at baseline and at 6 months.

Analysis: All quantitative variables were reported as the mean ± standard deviation. We used paired-samples t test for comparison of two means and Pearson correlation coefficient (n > 30) to check for correlations. Significance level was set at 0.05.

Results: Sixty (80%) women were reviewed at 6 months. There was a significant decrease in body mass index and fat mass and a significant increase of the percentage of lean mass. The total cholesterol, low-density lipoprotein cholesterol, C-reactive protein and leptin levels were reduced at 6 months.

Conclusion and implication: The prevention of the cardiovascular complications of the obesity for women of a modest socioeconomic level is achievable through readily accessible means.

Introduction

Obesity, a disorder associated with a myriad of comorbidities (diabetes, hypertension, dyslipidemia, cancer, cardiovascular diseases…), is increasing at an alarming rate around the word [1-3] and listed as the second leading cause of preventable death following cigarettes smoking. Facing the global obesity epidemic is a major public health challenge nowadays [4]. In Tunisia, the prevalence of obesity mainly among adult women increased from 7.8% in 1980 to 22.7% in 1997 [5] and to 37.7% in 2005 [6]. Currently, nearly 50% of Tunisian adult women are overweight or obese (Body mass index: > 25). Prevalence of overweight and obesity are higher among Tunisian women with lower education levels in urban areas [7]. Obesity was incremented in a quarter or more of diabetes cases [8]. The increasing prevalence of obesity and its strong association with comorbidities and mortality have prompted interest in identifying effective measures of weight control [9,10]. Given that, pharmacotherapy has limited available options and that bariatric surgery is reserved for those who are morbidly obese or who have significant comorbidities, the most common approach to the treatment of obesity is standard behavioral treatment [11,12]. This approach includes behavior modification related to eating and activity habits. Diet, a modifiable environmental factor, is a mainstay in the management of obese individuals. Creating a negative energy balance, by decreasing energy intake, increasing energy expenditure or both, is a common strategy for achieving weight loss. The search for a weight loss for its beneficial anthropometric, biological, and clinical effects is imperative in obese. The change in food intake (primarily energy restriction) for obese women remains an essential foundation of the dietetic treatment of obesity. Over the years, many dietary approaches have been tested as possible alternatives of treating obesity [13-18]. Unfortunately, data about the relative benefits, risks,

***Correspondence to:** Bellali Hédia, Faculty of Medicine of Tunis, El Manar University, Tunisia, Tel: 021670160361; 0021697066312; E-mail: hedia.bellali@gmail.com

***Key words:** obesity, women, energy restriction, Tunisia*

Received: January 03, 2020; **Accepted:** January 10, 2020; **Published:** January 13, 2020

metabolic effectiveness, and sustainability of different approaches have been limited. Dietary adherence has been implicated as an important factor in the success of dieting strategies; however, studies assessing and investigating its association with weight loss success are scarce. The various restrictive diets have shown their limits both by their low rates of adherence and their adverse health consequences.

In this context, we tested an approach based on a moderate energy restriction compared to what is usually consumed (American College of Cardiology/American Heart Association 2013). We have proposed a reduction of almost 50% of the usual energy consumption while improving habitual physical activity in obese women. The objective of this work was to measure the effectiveness of moderate energy restriction on weight loss and reduction of metabolic risk factors.

Material and methods

Participants

We conducted a nutritional intervention for a period of 6 months. The study involved volunteer obese women who were referred by a medical doctor. We included consecutively obese women who came to the Unit of obesity, Endocrinology service, La Rabta Hospital, Tunisia; to lose weight on January 2013. Inclusion criteria were a high body mass index greater or equal to 30 and a desire to lose weight. No other inclusion or exclusion criteria were applied. At the beginning, the rate of participation was 100% because all eligible women were included in the study. All post-program data provided by the participants were volunteered. Study's protocol was approved by the Rabta Hospital Ethics Committee and an informed written consent was obtained from all participants.

Outcome measures

Demographics, lifestyle behaviors, anthropometrics, biologic parameters and dietary intake were assessed at baseline and at 6 months with standard instruments. The women underwent an initial examination at time 0, a review at 6 months after the prescription of the diet without any contact in between.

Dietary intake

The dietary survey technique used to estimate usual nutrient intake was diet history. As first proposed by Burke the method consisted of an interview to obtain usual diet [19,20]. The diet history method does not involve recall over a specific period; it rather attempts to obtain a semi-quantitative picture of typical or habitual intake as reflected by intake in the immediate past. The main advantage of the diet history method is that if successfully carried out, it can provide an estimate of habitual intake for individuals [21,22]. Data were obtained during a face-to-face interview between the patient and a qualified nutritionist. In detail, the dietary interview allowed to quantify foods and drinks by using a photographic food atlas of known portion sizes to ensure accurate completion of the records [23]. For each meal the food frequency and the amount of food consumed by each individual was recorded. The participants were asked to recall the food intake during the immediate past 6 months. For each food, they were asked to mark a cross on the manual photos that they believed represented most closely the size of the portion they had consumed. This food photography manual has the advantage of being the first to represent a wide list of food usually consumed by the Tunisian population and requiring a visual aid for estimating portion sizes.

The usual dietary intake of participants was transformed into key macro and micronutrients using the NUTRISOFT BILNUT software version 2.01 whose food composition table has been supplemented by a list of food and especially Tunisian dishes.

Anthropometric measurements

The degree of obesity was established on the basis of Body Mass Index (BMI) cut-off points of 30.0–34.9 kg/m^2 (class I obesity), 35.0–39.9 kg/m^2 (class II obesity), and ≥ 40.0 kg/m^2 (class III obesity). Waist Circumference (WC) was measured to the closest 0.1cm with a non-extensible tape. The measurements were made with the subject standing upright, feet together, and arms hanging freely at the sides, with the subjects standing and breathing normally. WC was measured at the midpoint between the inferior costal margin and the upper iliac crest. We measured waist size as the mean of 2 readings at the umbilicus of the participant using a tape measure. At each intervention session, body weight (BW) was determined to the nearest 100 g using a calibrated balance beam scale with the participant in light clothing and not wearing shoes. The same balance accurate to ± 0.5 g was used for all measurements. This scale is widely used in the research and is known to provide valid measures of weight Percent weight reduction was calculated as [(initial BW – final observed BW) / initial BW] × 100%. Height without shoes was measured to the nearest centimeter, using a measuring rod. The determination of body composition: fat mass, lean mass was performed by bioelectrical impedance analysis. The BMI was computed as weight (kg) divided by height squared (m^2).

In all individuals, systolic (SBP) and diastolic (DBP) blood pressures were measured in three times, two minutes apart, with a random zero sphygmomanometer after the subject had been sitting for at least 10 min. The average of the second and third reading was recorded.

Fasting blood samples were collected in the morning after an overnight fast of 12 hours at baseline and 6 after months. We obtained blood samples after an overnight fasting on lithium heparin tubes for the lipid profile. The determination of total cholesterol (TC), triglycerides (TG) and HDL cholesterol (HDL-C) was produced by enzymatic colorimetric method on a Hitachi brand PLC Type 912. We used the Friedewald formula to calculate LDL cholesterol. Plasma concentrations of leptin were determined by radioimmunoassay. The dosage of adiponectin was directed by the Enzyme Linked Immunosorbeent Assay (ELISA, using radioimmunoassays and enzyme-linked immunosorbent assays). Hypertension was defined as SBP ≥ 140mmHg or DBP ≥ 90mmHg on two different occasions or taking antihypertensive medication. Hypercholesterolemia was defined as a fasting blood total cholesterol level ≥ 190 mg/dL or use of lipid-lowering medication, hypertriglyceridaemia as fasting blood TG levels ≥ 150 mg/dL or use of lipid-lowering medication [24].

Intervention

Exercise goal

Sedentary lifestyle is often assumed to be a contributing factor in obesity**.** The number of steps taken by an individual each day is considered as a marker of such activity. For instance, a sedentary lifestyle is defined as a daily step count that is less than 5,000 steps, whereas an active lifestyle is defined as a daily step count of more than 8,000–10,000 steps [25]. Throughout the obesity literature, the majority of studies combine numerous types of dietary interventions with various types of recommendations to increase physical activity ranging from basic advice to increase steps taken throughout the day (habitual activity) to carefully select and monitor exercise 'prescriptions. The choice of the model of physical activity proposed in our study, namely a reinforcement of the usual physical activities including walking and the domestic housework activities, was conditioned by physiological considerations which stipulate that the rate of oxidation of the lipids during exercise varies greatly from one individual to another (high inter individual variability) and is between 25 and 65% of VO2 max [26]. It is therefore very difficult to determine the rate of oxidation of the lipids of each person during the hospital medical consultations or nutritional surveys in order to indicate the intensity and duration of the adequate activity. On the other hand, the majority of the obese women retained in our study came from modest or unfavorable socioeconomic conditions that could not allow them to attend sport halls with expensive subscriptions or to equip themselves with home-suitable material (carpet, ergocycle...). Physical activity is not part of the habits of this Tunisian age group. The same is true for the low intellectual level of our population, which would have negatively affected the degree of adherence to the instructions for physical activity as demonstrated in other studies [27]. All participants were largely sedentary with low socio-economic status. Women were asked to improve the usual housewife physical activity and to maintain it during the 6 months intervention.

We did not provide an exercise program for participants, but only advised them to gradually increase habitual physical activity. Participants were instructed to increase their physical activity gradually, primarily via walking. Exercise during the program was not controlled, but regular low to moderate exertion was encouraged.

Energy and macro-nutrients gram goals

To achieve weight loss, an energy deficit is required. Several approaches can achieve energy deficit. First, specification of an energy intake target that is less than that required for energy balance, usually from 1 200 to 1 500 kcal/day for women and from 1 500 to 1 800 kcal/day for men (American College of Cardiology/American Heart Association 2013). The second approach consists of an estimation of individual energy requirements according to expert guidelines (World Health Organization 1985) and prescription of an energy deficit of 500 kcal/day or 750 kcal/day or 30 percent energy deficit. The nutritional intervention consisted of a prescription of 1600 Kcal/day with moderate macronutrient distribution providing 57% of energy as carbohydrate, 30% as fat, and 13% in the form of protein. It was demonstrated that an energy restriction respecting the balance between the macro-nutrients is more effective on the weight loss and fat mass decrease while maintaining the lean mass. Hypocaloric diets (1600 Kcal) were prescribed individually for all participants by expert dieticians at the Department of Nutrition, La Rabta University Hospital, Tunis. The diet was designed to provide 50% less energy than the baseline. The fat, carbohydrate and protein gram goal were 30%, 57% and 13% of the total daily calories according to the recommendations.

Measure of adherence

Adherence to the energy goal was calculated by dividing the total number of energy consumed by the calorie goal, then multiplying it by 100 to express the value as a percentage. Based on the calculation of adherence to the energy intake goals, participants were categorized as adherent (reported consuming 85%–115% of the daily goals) and non-adherent (reported consuming < 85% or > 115% of the daily goals [27].

Statistical analysis

Data were analyzed using SPSS software (version 20). Significance level was set at p value ≤ 0.05. All quantitative variables were reported as the mean ± standard deviation. The results are shown for the 6-months comparison to baseline measurements as means ± standard deviation for all parameters. Percentage change was calculated as:

$$\frac{\text{post test} - \text{pre test}}{\text{pre test}} * 100$$

Pretest refers to the value at T_0 and posttest refers to the value at T_6. To test for changes in anthropometric, clinical characteristics and dietary intakes before and after the program; we used paired-samples t test for comparison of two means in paired samples (n > 30) and Pearson correlation coefficient (n > 30) to check for correlations between quantitative variables.

Results

Study population consisted of 75 obese women. The baseline characteristics were summarized in Table 1. The average age of 75 obese women was 45.6 ± 12.1 years ranging between 20 and 68 years. BMI average was 40.6 ± 6.8 Kg/m2 (Table 1). BMI ranged from 30 to78 kg/m^2 with 45.3% of subjects have a BMI value greater than or equal to 40. The most present cardiovascular risk factors were hypertension (46.7%), diabetes (21.3%), hyperlipidemia (21.3%); 5.3% of the patients were tobacco smoking.

Of the 75 women enrolled in the initial review sixty (80%) were reviewed at 6 months. Table 2 showed the reported nutrients intake at baseline and after 6 months. The level of energy intake at 6 months of obese women (2572 Kcal) was higher than the recommended value prescribed (1600 Kcal). Analysis of nutritional intake (Table 2) showed a decrease (relative to baseline) of total energy intake (Kcal) (-12.2 ±

Table 1. Basic clinical and sociodemographic data of study participants (N=75)

	Mean	SD
Age (years)	45.3	12.1
Weight (Kg)	103.6	17.3
Waist circonference (cm)	116.6	12.8
BMI (Kg/m^2)	40.6	6.8
Fat mass (kg)	45.3	14.5
Fat mass (%)	43.6	5.7
Lean mass (kg)	57.5	5.5
Lean mass (%)	56.2	5.6
Systolic blood pressure	133.8	20.9
Diastolic blood pressure	78,7	12.2
Glucose (g/l)	1.17	0.51
Cholesterol total (g/l)	1.93	0.41
LDL cholesterol (g/l)	1.37	0.65
HDL cholesterol (g/l)	0.44	0.25
Triglycerides (g/l)	1.32	0.67
C-reactive protein (mg)	10.01	9.52
Leptin (ng/ml)	33.23	16.82
Comorbidity	n	%
Diabetes	16	21.3
Hypertension	35	46.7
Coronary artery disease	2	2.7
Hyperlipidemia	16	21.3
Cigarette smoking	4	5.3
Education		
None/primary	40	53.3
Secondary	22	29.3
Vocational/higher	10	13.3
Occupational activity		
No occupation	51	68
Laborer	10	13.3
Retired	1	1.3
Employed	10	13.3
Physical activity	9	12

22.7%), lipid (g) (9.8 ± 40.7%), carbohydrate (g) (-11.6 ± 27.5%) and increased protein intake as a percentage of energy intake (19.7 ± 70.8) at 6 months. As expected by the study protocol the energy distribution of macronutrients (57%, 30% and 13% of calories derived respectively from carbohydrate, fat, and protein), was respected at 6 months.

Change in anthropometric characteristics after 6 months was shown in Table 3. A significant reduction in body weight was seen after 6 months. Participants lost an average of 3 kg of body fat (*P* < 0.000). Change in waist circumference and fat mass were also similar to those seen weight. In women, mean (SD) body weight decreased by 2.9 ± 4.8 % (change from baseline) and waist size by 4.9 ± 5.8 %. Prior to starting the program, the mean BMI of participants was 40.3 ± 5.7kg/m^2. Mean reduction in BMI was -2.6 ± 5.2 (%), (*P* < 0.001) after the program. At the beginning study 45.3% of the subjects had a BMI value greater than or equal to 40 as against 36.5% after intervention. Weight reductions were highly associated with waist size reductions (Pearson correlation coefficient r = 0.60, p < 0.001) at 6 months.

Comparison of clinical characteristics before and after the 6 months program was shown in Table 4. Prior to the program the mean total cholesterol among participants was 1.97g/l, LDL-C was 2.15g/l, HDL-C was 0.44 g/l, and triglycerides were 1.31g/l. After 6 months, serum lipid profiles changed modestly.Restricted diet reduced mean total cholesterol, Cholesterol/HDL-ch (p < 0.01) and LDL-ch/HDL-ch (p=0.02). No effect of dietary treatment was evident in fasted plasma glucose and triglycerides at 6 months. The intervention diet reduced C-reactive protein levels significantly (-11.3 ± 54.9%, p < 0.001) and leptin level (-5.3 ± 90.1%, Table 4).

Discussion

In this study, we examined therapeutic efficacy of moderate energy restriction with a reinforcement of habitual physical activities by population for 6 months on dietary intake, anthropometry, body composition and biomarkers in obese women. Moderate energy restriction will prevent the physiological adaptation and the reduction of consecutive basic metabolism to a sizeable energy restriction [28]. It was demonstrated that an energy restriction respecting the balance between the macro-nutrients is more effective on the weight loss and fat mass decrease while maintaining the lean mass.

Sixty (80%) of the 75 women enrolled in the initial review were reviewed at 6 months. Such results are consistent with the literature. The choice of the model of physical activity proposed in our study, namely a reinforcement of the usual physical activities including walking and domestic housework activities, was conditioned by physiological considerations which stipulate that the rate of oxidation of the lipids during exercise varies greatly from one individual to another (high inter individual variability) and is between 25 and 65% of VO2 max [26]. It is therefore very difficult to determine the rate of oxidation of the lipids of each person during the hospital medical consultations or nutritional surveys in order to indicate the intensity and duration of the adequate activity. In addition, the majority of the

Table 2. Comparison of energy and macronutrient intake before and after 6 months program participation (n=60)

Nutrients	Baseline Mean ± SD	6 months Mean ± SD	Change (%) Mean ± SD	p value
Energy (Kcal)	2972 ± 572	2572 ± 683	-12.2 ± 22.7	**<0.001**
Protein (g)	87.6 ± 19.4	82.0 ± 19.2	-0.3 ± 45.7	0.060
Protein (%)	12.0 ± 1.4	14.4 ± 9.2	19.7 ± 70.1	0.052
Fat (g)	93.9 ± 28.0	78.1 ± 26.9	-9.8 ± 40.7	**0.001**
Fat (%)	28.5 ± 6.1	28.0 ± 6.5	-3.3 ± 35.1	0.654
Carbohydrate (g)	442.2 ± 96.4	382.9 ± 117.5	-11.6 ± 27.5	**<0.001**
Carbohydrate (%)	59.5 ± 6.2	59.1 ± 5.7	0.4 ± 14.5	0.715

SD: standard deviation, Kcal: kilo-caloric, g: grams.

Table 3. Comparison of anthropometric characteristics before and after 6 months program participation (n=60)

	Baseline Mean ± SD	6 months Mean ± SD	Change (%) Mean ± SD	P value
Weight (Kg)	102.4 ± 15.3	99.5 ± 16.2	-2.9 ± 4.8	**<0.001**
Waist circonference (cm)	116.2 ± 12.3	111.3 ± 12.3	-4.9 ± 5.8	**<0.001**
Fat mass (kg)	44.3 ± 12.5	42.5 ± 12.5	-6.3 ± 9.5	0.270
Fat mass (%)	43.5 ± 5.4	41.9 ± 6.1	-3.9 ± 5.5	**<0.001**
Lean mass (Kg)	57.2 ± 5.4	57.1 ± 5.4	-0.2 ± 2.1	0.800
Lean mass (%)	56.4 ± 5.4	57.9 ± 6.0	2.7 ± 5.1	**<0.001**
Body mass index (Kg/m^2)	40.3 ± 5.7	39.3 ± 6.2	-2.6 ± 5.2	**0.001**

SD: standard deviation, Kg: kilograms, cm: centimeter, m: meter.

Table 4. Comparison of clinical characteristics before and after 6 months program participation (n= 60)

	Number	Baseline Mean ± SD	6 months Mean ± SD	Change (%) Mean ± SD	P value
Glucose (g/l)	54	1.20 ± 0.55	1.21 ± 0.68	2.1 ± 38.4	0.53
Cholesterol (g /l)	55	1.97 ± 0.43	1.91 ± 0.42	-2.7 ± 10.5	**0.025**
HDL-ch (g/l)	52	0.44 ± 0.27	0.44 ± 0.09	5.8 ± 17.3	0.86
LDL-ch (g/l)	52	2.15 ± 0.50	2.07 ± 0.39	-11.3 ± 41.9	0.17
Cholesterol/HDL-ch	52	4.70 ± 1.43	4.37 ± 1.29	1.35 ± 68	**0.010**
LDL-ch/HDLch	52	3.03 ± 1.16	2.71 ± 1.09	-35.1 ± 172	**0.002**
Triglycerides (g)	55	1.31 ± 0.68	1.39 ± 0.79	12.2 ± 50.5	0.40
C-reactive protein(g)	43	8.39 ± 10.60	6.53 ± 5.58	-11.31 ± 54.9	**0.005**
Leptin (ng/ml)	30	34.01 ± 16,56	31.50 ± 24.19	-5.3 ± 90.1	0.57

SD: standard deviation, g: grams, g/l: grams/liter, mg: milligrams, ng/ml: nanograms /milliliters,
*: p < 0.05, ND: Not determined

obese women included in our study came from modest or unfavorable socioeconomic conditions that could not allow them to attend sports halls with expensive subscriptions or to equip themselves with home-suitable material (carpet, ergocycle...). Physical activity is not part of the habits of this Tunisian age group. The same is true for the low intellectual level of our population, which would have negatively affected the degree of adherence to the instructions for physical activity as demonstrated in other studies. All participants were largely sedentary with lower socio-economic status. Women were asked to improve the usual housewife women physical activity and to maintain it during the 6 months intervention. Compared with being inactive, doing half the recommended amount of physical activity is associated with a lower incidence of several common biological cardiovascular diseases risk factors. Given these benefits, half the recommended amount of physical activity is an evidence based target for inactive adults [29].

It seems that the significant reduction in energy intake, lipid and carbohydrate contributed to the weight loss seen in the obese. A significant positive correlation between changes in fat intake (percentage) and BMI was observed (r=0.420, p=0.001) in our obese which is consistent with the results of the study Field, *et al.* [30]. These beneficial effects of a moderate fat intake seem to be related to both the quantity and quality of dietary fat [31]. Diets rich in unsaturated fats, including mono-unsaturated fats and poly-unsaturated fats, compared to diets high in saturated fats, are more metabolically beneficial for weight loss due to the higher thermogenesis and fat oxidation. Long-term dietary interventions also support the notion that unsaturated fats induce greater energy expenditure, diet-induced thermogenesis, and/or fat oxidation versus saturated fatty acids and that a high monounsaturated fatty acids diet induces more weight loss compared to a high saturated fatty acids diet [32].

Adherence rate was 20%. A meta analysis [27] has shown that intervention overall adherence rate was 60.5 (10% to 99.5%). Understanding the reasons for non-adherence can facilitate intervention strategies. Several studies discussed factors associated with lower adherence. These included lower socioeconomic status (education and income), higher weight. Others studies [33] found associations between higher adherence and older age, higher income, and higher education. Increased adherence appears to be associated with greater weight loss and cardiac risk factor reduction [27]. Programs supervising attendance, offering social support, and focusing on dietary modification have better adherence than interventions not supervising attendance, not offering social support, and focusing exclusively on exercise [27]. Implementation of short-term patient empowerment as applied to Mediterranean diet adherence was shown to improve anthropometric and metabolic parameters in prediabetic overweight or obese subjects. This is of considerable importance, given that diet must be the cornerstone of treatment in patients with type 2 diabetes [33]. A good working relationship with health care professionals is described as an important factor in long-term weight management [34].

The results show that the intervention leads to significant weight loss. The average weight loss observed at 6 months is 2.8 ± 5.4 kg (2.8 ± 4.8%). Although the magnitude of the weight loss associated with intervention seems rather modest, it is similar to that reported by other studies. It is well established that even a modest weight loss of 5% is associated with health benefits [35,36]. This amount of weight loss is typically associated with positive clinical effects, namely an improvement in cardiovascular risk factors [37]. Weight reductions were highly associated with waist size reductions (r=0.60 at 6 months; P < 0.001).Changes in other anthropometric parameters associated with cardiovascular risk, including BMI, body fat percentage, and waist circumference were also significant in this study, similar to other interventions [37]. BMI, waist circumference, and fat mass decreased after program participation. On the other hand, lean mass (percentage) increased by 2.7 ± 5.1% at 6 months. The loss of fat can be negated to some degree by a corresponding rise in lean muscle mass, which leads to difficulties in interpreting results when outcome is assessed solely by changes in body weight. On the other hand, lean mass (percentage) increased by 2.7 ± 5.1% at 6 months. The loss of fat can be negated to some degree by a corresponding rise in lean muscle mass, which leads to difficulties in interpreting results when outcome is assessed solely by changes in body weight.

The present findings showed that twenty-four weeks individualized training program may induce small to moderate effect on blood biomarkers, in terms of glucose, TG, HDLch in obese women. These results are consistent with other studies. Lang, *et al.* reported a 3.2% reduction in body weight in response to a program for 8 weeks associated with physical activity and nutrition education did not cause a reduction in concentrations of fasting glucose, despite the observed improvements in blood lipid profiles [38]. It appears that the serum lipid profiles are more sensitive to the modest weight loss than the concentration of glucose in the blood. A decrease in C-reactive protein (p < 0.01) and leptin level was observed at 6 months. Leptin and adiponectin are adipose tissue-specific proteins, and obese people are reported to have higher leptin and lower adiponectin concentrations. In the present study, average serum leptin decreased after 6 months in obese women. This is consistent with the finding that at least 5% weight loss is necessary to decrease the concentrations of leptin in obese people. The results of Klempel study demonstrated that even a slight loss of weight induced by energy restriction can have beneficial effects on leptin levels, but it has no clear impact on the adiponectin [39]. Obesity is associated with increased blood levels of CRP. A decrease in C-reactive protein (p < 0.01) was observed at 6 months. A systematic review concluded that weight loss through various mechanisms reduces CRP [40]. Dietary intervention designed to elicit weight loss with or without exercise reduced overall inflammation in obese women [41].

An important strength of our study is the choice of an intervention based on a careful consideration of the target population's characteristics: a combination of dietary changes and a encouragement to engage in types of physical activities that were judged as easily accessible by the studied women. Compared with being inactive, doing half the recommended amount of physical activities is associated with a lower incidence of several common biological cardiovascular diseases risk factors [30]. Given these benefits, half the recommended amount of physical activity is evidence-based target for inactive adults.

Based on the data presented, it is clear that moderately restricted energy diets with moderate energy distribution of macronutrients and a reinforcement of the usual physical activities including walking and the domestic housework activities can reduce weight and improve metabolic markers in obese patients. But as with most diets' energy restriction is difficult to maintain long-term, and therefore the positive health outcomes are not usually kept. Increased adherence appears to be associated with greater weight loss and cardiac risk factor reduction. To optimally manage a national epidemic of excess body weight and associated cardiac risk factors, practical techniques to increase dietary adherence rates are urgently needed.

There were several limitations. The results should be interpreted with caution given the absence of a control group and that future studies with Randomized Control Trials design are needed. The extrapolation of our results to a more heterogeneous population might be limited because the women included in our study were lowly educated and comprised a fairly homogenous population. However, the metabolic characteristics are generally consistent with those observed in the obese population in Tunisia [7,9,10]. Thus, the sample of our study is not different from the Tunisian obese women population. Our study is also limited by the use of self- reported dietary and physical activity data, which may result in under or over reporting of these measures. Our study was not having a control comparison which may limit the accuracy of comparison. The extrapolation of our results to a more heterogeneous population might be limited because the women included in our study were lowly educated and comprised a fairly homogenous population. Thus, the sample of our study is not different from the Tunisian obese women population

Implications for research and practice

Based on the data presented, it is clear that moderately restricted energy diets with moderate energy distribution of macronutrients and a reinforcement of the habitual physical activities including walking to go shopping and the domestic housework activities can reduce weight and improve metabolic markers in obese patients. But as with most diets' energy restriction is difficult to maintain long-term, and therefore the positive health outcomes are not usually kept. Behavior change requires time and must be maintained. At this maintenance period, numerous barriers, including the absence of social support, a lack of time management, health status changes, life transitions, and lack or decline of motivation can impact on the original success of weight loss. To optimally manage a national epidemic of excess body weight and associated cardiac risk factors, practical techniques to increase dietary adherence rates are urgently needed. Furthermore, a good working relationship with health care professionals is described as an important factor in long term weight.

References

1. Lavie CJ, Arena R, Alpert MA, Milani RV, Ventura HO (2018) Management of cardiovascular diseases in patients with obesity. *Nat Rev Cardiol* 15: 45-56. [Crossref]
2. World Health Organization Fact Sheets (2018) Retrieved form : http://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight.
3. Afshin A, Forouzanfar MH, Reitsma MB, Sur P, Estep K, Lee A, et al. (2017) GBD 2015 Obesity Collaborators. Health effects of overweight and obesity in 195 Countries over 25 Years. *N Engl J Med* 377: 13-27.
4. Blüher M (2019) Obesity: global epidemiology and pathogenesis. *Nat Rev Endocrinol* 15: 288-298. [Crossref]
5. Mokhtar N, Elati J, Chabir R, Bour A, Elkari K, et al. (2001) Diet culture and obesity in northern Africa. *J Nutr* 131: 887S-892S. [Crossref]
6. Traissac P, El Ati J, Gartner A, Ben Gharbia H, Delpeuch F (2016) Gender inequalities in excess adiposity and anaemia combine in a large double burden of malnutrition gap detrimental to women in an urban area in North Africa. *Public Health Nutr* 19: 1428-1437.
7. Gharbi M, Bel Hani A, Aouidet A, Ben Rayana Ch, Achour A, et al. (1996) Level of cardiovascular risk factors in the urban and rural populations of Cap-Bon: Tunisia. Rev Epidémiol Santé Publique 44: 125-132.
8. Maoui A, Bouzid K, Ben Abdelaziz A, Ben Abdelaziz A (2019) Epidemiology of Type 2 Diabetes in the Greater Maghreb. Example of Tunisia. Systematic review of the literature. *Tunis Med* 97: 286-295.
9. Saidi O, O'Flaherty M, Mansour NB, Aissi W, Lassoued O, et al. (2015) ECFP7 funded MEDCHAMPS project. Forecasting Tunisian type 2 diabetes prevalence to 2027: validation of a simple model. *BMC Public Health* 5: 1-8.
10. Tlili F, Tinsa F, Skhiri A, Zaman S, Phillimore P, et al. (2015) Living with diabetes and hypertension in Tunisia: popular perspectives on biomedical treatment. *Int J Public Health* 60 : S31-S37.
11. Bray GA, Frühbeck G, Ryan DH, Wilding JP (2016) Management of obesity. *Lancet* 387: 1947-1956. [Crossref]
12. Beleigoli AM, Andrade AQ, Cançado AG, Paulo MN, Diniz MFH, et al. (2019) Web-Based Digital Health Interventions for Weight Loss and Lifestyle Habit Changes in Overweight and Obese Adults: Systematic Review and Meta-Analysis. *J Med Internet Res* 21: e298.
13. Johns DJ, Hartmann-Boyce J, Jebb SA, Aveyard P (2014) Diet or exercise interventions vs combined behavioral weight management programs: a systematic review and meta-analysis of direct comparisons. *J Acad of Nutr* Diet 114: 1557–1568.
14. Sylvetsky AC, Edelstein SL, Walford G, Boyko EJ, Horton ES, et al, (2017) Diabetes Prevention Program Research Group. A High-Carbohydrate, High-Fiber, Low-Fat Diet Results in Weight Loss among Adults at High Risk of Type 2 Diabetes. *J Nutr* 147: 2060-2066.
15. Hamdy O, Tasabehji MW, Elseaidy T, Tomah S, Ashrafzadeh S, et al. (2018) Fat Versus Carbohydrate-Based Energy-Restricted Diets for Weight Loss in Patients With Type 2 Diabetes. *Curr Diab Rep* 18: 128.
16. Stockman MC, Thomas D, Burke J, Apovian CM (2018) Intermittent Fasting: Is the Wait Worth the Weight? *Curr Obes Rep* 7: 172-185. [Crossref]
17. Paoli A, Tinsley G, Bianco A, Moro T (2019) The Influence of Meal Frequency and Timing on Health in Humans: The Role of Fasting. *Nutrients* 11. [Crossref]
18. Cioffi I, Evangelista A, Ponzo V, Ciccone G, Soldati L, et al. (2018) Intermittent versus continuous energy restriction on weight loss and cardio metabolic outcomes: a systematic review and meta-analysis of randomized controlled trials. *J Transl Med* 16: 371.
19. Willet WC (2013) Nutritional epidemiology. 3rd ed. New York: Oxford University Press pp: 107-112.
20. Rosilene WV, Cumming R, Travison T, Blyth F, Naganathan V, et al. (2015) Relative validity of a diet history questionnaire against a four-day weighed food record among older men in Australia: The Concord Health and Ageing in Men Project (CHAMP). *J Nut Health Aging* 19: 603-610.
21. Yokoyama Y, Takachi R, Ishihara J, Ishii Y, Sasazuki S, et al. (2016) Validity of short and long self-administered food frequency questionnaires in ranking dietary intake in middle-aged and elderly Japanese in the Japan Public Health Center-Based Prospective Study for the Next Generation (JPHC-NEXT) Protocol Area. *J Epidemiol* 26: 420-432.
22. Rutishauser IH (2005) Dietary intake measurements. *Public Health Nutrition* 8: 1100-1107.
23. Bouchoucha M, Akrout M, Bellali H, Bouchoucha R, Tarhouni F, et al. (2016) Development and validation of a food photography manual, as a tool for estimation of food portion size in epidemiological dietary surveys in Tunisia. *Libyan J Med* 11: 1-9.
24. Mancia G, De Backer A, Dominiczak A, Cifkova R, Fagard R, et al. (2007) "2007 Guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC)," *Eur Heart J* 28: 1462-1536.
25. Swift DL, Johannsen NM, Tudor-Locke, C, Earnest CP, Johnson WD, et al. (2012) Exercise training and habitual physical activity: a randomized controlled trial. *Am J Prev Med* 43: 629-635.
26. Romijn JA, Klein S, Coyle EF, Sidossis LS, Wolfe RR (1993) Strenuous endurance training increase lipolysis and triglycerides-fatty acid cycling at rest. *J Appl Physiol* 75: 108-113.
27. Lemstra M, Bird Y, Nwankwo C, Rogers M, Moraros J (2016) Weight loss intervention adherence and factors promoting adherence: a meta-analysis. *Patient Prefer Adherence* 10: 1547-1559.
28. Müller MJ, Enderle J, Pourhassan, M, Braun W, Eggeling, B, et al. (2015) Metabolic adaptation to caloric restriction and subsequent refeeding: the Minnesota Starvation Experiment revisited. *Am J Clin Nutr* 102: 807-819.
29. Martinez-Gomez D, Esteban-Cornejo I, Lopez-Garcia E, García-Esquinas E, Sadarangani KP, et al. (2018) Physical activity less than the recommended amount may prevent the onset of major biological risk factors for cardiovascular disease: a cohort study of 198?919 adults. *Br J Sports Med*.
30. Field AE, Willett WC, Lissner L, Colditz GA (2007) Dietary fat and weight gain among women in the Nurses' Health Study. *Obesity (Silver Spring)* 15: 967-976. [Crossref]
31. Fleming JA, Kris-Etherton PM (2016) Macronutrient Content of the Diet: What Do We Know About Energy Balance and Weight Maintenance? *Curr Obes Rep* 5: 208-213.
32. Krishnan S, Cooper JA (2014) Effect of dietary fatty acid composition on substrate utilization and body weight maintenance in humans. *Eur J Nutr* 53: 691-710. [Crossref]

33. Muscogiuri G, Barrea L, Di Somma C, Altieri B, Vecchiarini M, et al. (2019) Patient empowerment and the Mediterranean diet as a possible tool to tackle prediabetes associated with overweight or obesity: a pilot study. *Hormones (Athens)* 18: 75-84.

34. Brandt CJ, Søgaard GI, Clemensen J, Søndergaard J, Nielsen JB (2018) Determinants of successfule Health coaching for consumer lifestyle changes: qualitative interview study among health care professionals. *J Med Internet Res* 20: e237.

35. Kuk JL, Wharton S (2016) Differences in weight change trajectory patterns in a publicly funded adult weight management centre. *Obes Sci Pract* 2: 215-223.

36. Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, et al. (2014) Guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. Circulation 129: S102-S138.

37. Haas K, Hayoz S, Maurer-Wiesner S (2019) Effectiveness and Feasibility of a Remote Lifestyle Intervention by Dietitians for Overweight and Obese Adults: Pilot Study. *JMIR Mhealth Uhealth* 7: e12289.

38. Lang HF, Chou CY, Sheu WH, Lin JY (2011) Weight loss increased serum adiponectin but decreased lipid levels in obese subjects whose body mass index was lower than 30 kg/m^2. *Nutr Res* 31: 378-386.

39. Klempel MC, Varady KA (2011) Reliability of leptin, but not adiponectin, as a biomarker for diet-induced weight loss in humans. *Nutr Rev* 69: 145-154. [Crossref]

40. Choi J, Josef L, Pilote L (2013) Obesity and C-reactive protein in various populations: a systematic review and meta-analysis. *Obes Rev* 14: 232-244.

41. Camhi SM, Stefanick ML, Ridker PM, Young DR (2010) Change in C-reactive protein from low-fat diet and/or physical activity in men and women with and without metabolic syndrome. *Metabolism* 59: 54-61.