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The effects of different caloric restriction diets on anthropometric and cardiometabolic risk factors in overweight and obese females

Uticaj različitih kalorijskih ograničenja u ishrani na antropometrijske i kardiometaboličke faktore rizika kod predgojaznih i gojaznih žena

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Abstract

Background/Aim. Obesity is an established risk factor for numerous chronic diseases. The aim of this study was to investigate the effect of well-balanced different caloric restriction (CR) diets on anthropometric parameters and standard biochemical cardiovascular risk markers [lipid profile, glucose homeostasis and high sensitivity C-reactive protein (hs-CRP)] in overweight/obese females. **Methods.** Participants (age 20–40 years) were randomized into 3 different CR diet groups: the group I – restriction of 20% calories from baseline energy requirements, the group II – restriction of 50% calories from baseline energy requirements and the group III – alternating daily diets with 70%/30% restriction. The study lasted 42 weeks. Anthropometric parameters were measured at the start and after 4, 8, 20 and 42 weeks after dietary intervention beginning. Biochemical markers were determined at baseline and after 20 and 42 weeks from dietary restriction start. **Results.** Body weight, body mass index (BMI), waist circumference (WC) and body fat (in %), in the different CR diet groups significantly decreased after 42 weeks. Body weight was less 11 kg in the group I and 12 kg in the groups II and III. WC was reduced by 11 cm in the groups I and III and by 10 cm in the group II. Different CR diets had the same effects on body fat (a reduction of 15% of body fat). Total cholesterol decreased by 7% in the group I and by 8% in the group III. Low density lipoprotein (LDL) cholesterol decreased by 14% in the group I and by 13% in group III. There were no significant changes in total and LDL-cholesterol levels in the group II. The atherogenic index presented as trigliceride/high density lipoprotein (TG/HDL) ratio decreased by 0.22 in the group I, by 0.25 in the group II and by 0.32 in the group III. Various CR diets had the same effects on reducing the hs-CRP levels. **Conclusion.** Different CR diets with the same macronutrient content are equally effective in reducing body weight, WC and body fat, improve cardiometabolic risk factors and decrease level of pro-inflammatory hs-CRP in overweight/obese females.

Key words:
diet, reducing; anthropometry; obesity; women; lipoproteins; glucose; c-reactive protein; body mass index.

Apstrakt

Uvod/Cilj. Gojaznost je faktor rizika od nastanka mnogih hroničnih bolesti. Cilj istraživanja bio je da se ispita efekat dobro izbalansirane ishrane različitih kalorijskih ograničenja na antropometrijske parametare i standardne biohemijske kardiovaskularne markere rizika [(lipidni profil, homeostazu glukoze, visoko senzitivni C-reaktivni protein – high-sensitivity C-reactive protein (hs-CRP)] kod predgojaznih/gojaznih žena. **Metode.** Ukupno 97 žena, između 20 i 40 godina starosti, konzumirale su uravno-težene, kalorijski različite-restriktivne dijete, na sledeći način: I grupa (n = 37) – ograničenje 20% kalorija od osnovnih energetskih potreba; II grupa (n = 30) – ograničenje od 50% kalorija od osnovnih energetskih potreba i III grupa (n = 30) – naizmenična dnevna restrikcija od 70% i 30% kalorija od osnovnih energetskih potreba. Stepen uhranjenosti je određivan antropometrijskim merenjima na početku i nakon 4, 8, 20 i 42 nedelje od uvođenja dijeta. Biohemijski markeri analizirani su na početku i nakon 4, 8, 20 i 42 nedelje. **Rezultati.** Kalorijski različite restriktivne dijete dovele su do značajnog smanjena telesne mase, indeksa telesne mase (*body mass index* – BMI), obima stuka (OS) i % telesne masti nakon tretmana

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od 42 nedelje. Telesna masa snižena je za 11 kg u grupi I, a za 12 kg u grupama II i III. Za 11 cm je smanjen OS u grupama I i III i za 10 cm u grupi II. Gubitak 15% ukupne telesne masti ostvaren je za sve vrste dijeta nezavisno od različitog kalorijskog unosa. Koncentracija ukupnog i (*low density lipoprotein*) holesterola (LDL-holesterola) snižena je za 7% i 14% u grupi I i za 8% i 13% u grupi III. Dijeta sa redukcijom kalorijskog unosa od 50% nije imala efekta na nivo ukupnog i lipoprotein niske gustine LDL-holesterola. Aterogeni indeks predstavljen kao odnos trigliceridi/lipoprotein visoke gustine (*high density lipoprotein*) – TG/HDL bio je manji za 0,22 u grupi I, za 0,25 u grupi II i za 0,32 u grupi III. Kalorijski različite restriktivne dijete dovele su do istog sniženja nivoa hs-CRP. **Zaključak.** Restriktivne vrste dijeta sa različitim kalorijskim unosom i sa istim procentom zastupljenosti makronutrijenata jednako su efikasne u smanjenju telesne mase, OS i % telesne masti, dovode do poboljšanja faktora kardiometaboličkog rizika i smanjenja proinflamatornog hs-CRP kod predgojaznih/gojaznih žena.

Ključne reči:
dijeta, redukciona; antropometrija; gojaznost; žene; lipoproteini; glukoza; c-reaktivni protein; telesna masa, indeks.

Introduction

Increasing obesity is declared as a huge public health problem in the world. Some of chronic diseases are closely related to the existing obesity. These are atherosclerosis, hypertension, hyperlipidemia, insulin resistance syndrome [1, 2], musculoskeletal diseases, polycystic ovary syndrome, some types of cancer and lack of a sense of psychological well-being. Serbia has a growing population of overweight people in the last ten years, too [3]. In fact, about 35% of adult population are overweight and 21% considered obese [4]. Metabolic risk factors are closely related to nutrition status and body composition. Inflammation and cardiovascular diseases are result of obesity [1, 5].

Waist circumference (WC) is most commonly used as an indicator of abdominal adiposity [6]. Obesity with a combination of abdominal obesity is related to metabolic disorders such as dyslipidemia and hyperinsulinemia, disrupted homeostasis and inflammation [2, 5]. Nutritional therapy is a sovereign method in achieving weight loss. [7] Calorie restrictive (CR) diets with energy limitation and balanced macronutrient composition are most often applied [8, 9]. The success in achieving weight loss is determined with degree of calorie restriction.

Calorie restrictive diets consist of reducing energy intake by 15–60% of common daily energy requirements. Obesity treatment guidelines issued by the National Institute of Health considered a good reduction in caloric intake by 500 kcal/day in the treatment of overweight and the class I obesity. This level of CR diet is recommended to people with diagnosed more than one risk factor, too [10].

Low-calorie diets (LCDs) are high in carbohydrate (55–60%) and low in fat (less than 30% of caloric intake). Also, LCDs have a low glycemic index, but a high fiber content. There is a solid evidence that indicates that LCDs during a period of 3–12 months, can lower total body weight by an average of 8% [10, 11]. Thus, it is implicated that CR may be critical factor in determining the results of intervention.

Different dietary interventions with weight loss, decrease of abdominal obesity, an achievement of desirable values of serum cholesterol, triglycerides and fasting insulin concentrations glucose tolerance and blood pressure as a goal have been set in the last decades [12–14].

To our knowledge, the number of studies that have examined the influence of different dietary intervention on enhancing weight loss and reducing cardiometabolic risk factors including blood lipids profile, glucose homeostasis and inflammation are limited. Therefore, the aim of this study was to investigate the long-term effects of well-balanced diet with different CR on anthropometric parameters, body fat mass and standard biochemical cardiovascular risk markers, e.g., lipid profile, parameters of glycoregulation and high-sensitive C-reactive protein (hs-CRP) in overweight and obese females.

Methods

Participants

We designed a follow-up, prospective, intervention study in the routine management of 240 overweight or obese females that attended the Department of Nutrition, Institute of Hygiene, Military Medical Academy (MMA) and were initially enrolled from January 2014 to May 2015. Due to the high drop-off rate, 97 females with baseline body mass index (BMI) ≥ 25 kg/m^2, completed the study.

Key inclusion criteria were: female gender, age 20–40 years, BMI between 25 and 44.9 kg/m^2, stable weight (± 2 kg) and sedentary or lightly active status for 3 months before beginning of the intervention, with normal fasting glucose levels. Subjects that had history of cardiovascular disease, liver or kidney dysfunction or cancer, taking weight loss, lipid-lowering, or glucose-lowering medications were excluded. The study was approved by the Human Research Ethics Committee of the MMA. Written consent was signed by all study participants at the start of the study.

Study design

Participants were matched for age and BMI, and then were randomly selected using computer-generated random number allocation for consumption of different well-balanced caloric restriction diets during 42 weeks.

Participants were selected into one of three groups: the group I (n = 37) – restriction of 20% calories from baseline energy requirements; the group II (n = 30) – 50% CR from baseline energy requirements and the group III (n = 30) – 70%/30% CR alternating daily diets (one day 70%

and the following day 30% caloric restriction, respectively from baseline energy requirements). Participants in the CR groups were educated by our medical dietitian on principles to reduce their daily energy intake in order to achieve weight reduction.

After careful consideration of global nutrition, a personalized CR diet (700–1700 kcal/day) was prescribed, aiming at the achievement of a moderate weight loss. These low and moderate calories diets are based on conventional-type of intervention. In general, diets are low in energy and fat caloric intake with high carbohydrate and fibre content, based on an increased intake of whole grain cereals, vegetables and fruit [10]. Proposed food plan included carbohydrates (55–60% of total calories with 14 g dietary fibre/1,000 kcal), proteins (15–20% of total calories with 1.0 g/kg body weight/day), dietary cholesterol lower than 300 mg/day and limit of fat intake to < 30 % of total calories (with limit of saturated fatty acid to < 10 % of total calories intake) mostly mono and polyunsaturated fats. [10, 11] The CR diets were also balanced in terms of micronutrients intake (vitamins and minerals in the recommended diet must always be checked). On a very LCDs, weight losses for women have been reported to be 1.5–2 kg/week with the average weight loss of 20 kg during 12 weeks. Low-energy diet for 20–24 weeks, lead to reduce of 0.4–0.5 kg/week with the average weight loss of 8.5 kg. [15] There was no special physical activity prescribed during the study. Individuals met with our medical dietician at baseline, and after 4 and 8 weeks and later were followed monthly. The initial weight-loss goal was expected to be 10% over during 10-month dietary treatment period.

Anthropometric parameters

Anthropometric parameters were measurement at baseline and after 4, 8, 20 and 42 weeks in three different CR groups. A qualified nutritionist conducted anthropometric measurements. Body weight and height were measured and BMI was calculated. The height and weight of the participants dressed in light clothing without shoes were determined. Standard measurements of body height were performed. Obesity was classified, according to the World Health Organization (WHO) guidelines. [5, 10] Percentage of body fat was calculated from thickness of skinfolds on 4 measured points [16]. After measurements of WC subjects were classified into 3 groups according to health risk [17] Anthropometric measurements were taken by one person.

Biochemical analyses

At baseline, after 20 weeks and at the end of dietary treatment (week 42), fasting blood samples were collected from all participants. The serum concentration of glucose, hemoglobin glucosylated test (HbA1C), triacylglycerols (TG), total cholesterol (TC), high-density lipoprotein (HDL)-cholesterol and hs-CRP were measured using enzymatic kits (*Roche Diagnostics, Basel, Switzerland*) on a Siemens autoanalyser (*Dimension®, RxL Max, Siemens Dade Behring*). Calculations mde were: low-density lipoprotein (LDL) cholesterol via the Friedewald formula, [18] and atherogenic index as TG/HDL cholesterol ratio. We established a cut-off value of 5% at 6 months to indicate the efficacy of treatment.

Statistical analysis

Anthropometric parameters and concentrations were presented as mean values ± standard deviation (SD) and statistically analyzed by SPSS 20 software (IBM, Armonk, NY, USA). Since all variables showed normal distribution, checked by Shapiro Wilk test, univariate analysis of variance (ANOVA) was performed to assess differences in baseline characteristics and dietary data among CR groups. The effect of a diet duration (time 0–42 weeks) and the diet itself (different CR treatments) on continuous variables was determined using repeated ANOVA (taking time as within-subject factor and a diet as between-subject factor) to assess differences among different CR diet groups during the study (effect: time x CR group). *Post hoc* analyses were applied with Bonferroni adjustments for multiple parameters comparisons. Differences among groups were assessed by repeated ANOVA, followed by Tukey *post hoc* test. P values < 0.05 indicated statistical significance.

Results

Two hundred and forty subject were assessed at the begining of the study (week 0) and 97 subject (the group I – 20% CR, n = 37, the group II – 50% CR, n = 30, the group III – 70/30% CR, n = 30), who represent approximately 40% of the participants from the beginning of the study, completed dietary interventions after 42 weeks. At the beginning , various CR diet groups were similar in most parameters that were monitored, except WC, serum fasting glucose and hs-CRP levels, which were significantly lower in the group III with 70%/30% alternating daily CR compared to baseline levels in the group I – 20% CR and the group II – 50% CR (Table 1).

During the study period of 42 weeks, different CR groups had similar reductions in body weight, percentage of body fat and WC (time 0–42 weeks: $p < 0.001$; effect: time x CR diet group; $p > 0.05$) (Table 1). All CR-diet groups achieved a weight loss of 5% of their initial body weight after 4 weeks of the treatment. Waist circumference decreased ($p < 0.001$) by 11 cm in the group I (20% CR) and by 12 cm in the group II (50% CR) and the group III (70%/30%) from initial values during weight loss period, despite that WC was low at baseline in the group III (70%/30%) compared to other two CR groups. Different caloric restriction diets had the same reduction of 15% of total body fat compared to baseline (different treatments $p = 0.432$, time 0–42 weeks: $p < 0.001$). Table 1 shows that during treatment period, BMI in different CR diet groups

Table 1

Antropometric parameters and body fat before and after 4, 8, 20 and 42 weeks consummation of different calorie restrictive (CR) diets

Parameters	Group I – 20% CR (n = 37) x̄ ± SD	Group II – 50% CR (n = 30) x̄ ± SD	Group III – 70%/30% CR (n = 30) x̄ ± SD	Different treatment [c] (probability)	Time interval 0–42 weaks [d] (probability)	Effect Time x CR group [e] (probability)
Age (years)	31 ± 8	32 ± 8	32 ± 7			
Height (cm)	167 ± 6	166 ± 6	168 ± 5			
Weight (kg) by week						
0	84.70 ± 13.52	85.62 ± 11.87	82.73 ± 10.99			
4	80.49 ± 13.38	81.38 ± 11.89	78.41 ± 10.85			
8	78.30 ± 12.93	78.59 ± 11.39	75.77 ± 10.41	$p = 0.047$ [c]	$p < 0.001$ [d]	$p = 0.002$ [e]
20	75.50 ± 12.90	75.35 ± 11.07	73.10 ± 10.25			
42	73.67 ±12.09	73.29 ± 10.98	70.84 ± 10.18			
Weight changes (kg) by week intervals						
0–4	-4.21 ± 2.61	-4.23 ± 1.19	-4.32 ± 1.83			
0–8	-6.70 ± 3.08	-7.23 ± 2.31	-6.96 ± 2.38			
0–20	-9.20 ± 7.91	-10.26 ± 5.60	-9.63 ± 3.78			
0–42	-11.03 ± 3.64	-11.93 ± 5.55	-11.89 ± 4.06			
BMI (kg/m^2) by week						
0	30.19 ± 3.93	30.93 ± 4.39	29.29 ± 3.79			
4	28.67 ± 3.92	29.39 ± 4.37	27.76 ± 3.74			
8	27.88 ± 3.79	28.38 ± 4.19	26.83 ± 3.60	$p = 0.257$ [c]	$p < 0.001$ [d]	$p = 0.473$ [e]
20	26.44 ± 4.08	27.23 ± 3.14	25.88 ± 3.56			
42	26.24 ± 3.60	26.49 ± 4.14	25.05 ± 3.50			
BMI changes (kg/m^2) by week intervals						
0–4	-1.52 ± 0.91	-1.54 ± 0.46	-1.54 ± 0.63			
0–8	-2.31 ± 1.05	-2.55 ± 0.79	-2.46 ± 0.83			
0–20	-3.75 ± 2.89	-3.60 ± 1.99	-3.41 ± 1.34			
0–42	-3.95 ± 1.23	-4.44 ± 1.96	-4.74 ± 1.61			
WC (cm) by week						
0	96.82 ± 10.46**	95.88 ± 13.29*	91.03 ± 10.70			
4	92.04 ± 11.293	93.63 ± 12.18	86.92 ±10.24			
8	92.01 ± 10.52	91.12 ± 11.81	84.80 ± 9.97	$p = 0.046$ [c]	$p < 0.001$ [d]	$p = 0.637$ [e]
20	88.55 ± 10.36	87.87 ± 10.95	81.85 ± 9.04			
42	85.78 ± 16.94	85.51 ± 10.80	80.30 ± 9.34			
WC changes (cm) by week intervals						
0–4	-4.78 ± 2.86	-2.25 ± 2.86[b]	-4.11 ± 3.02			
0–8	-4.81 ± 4.67	-4.75± 6.73	-6.23 ± 3.68			
0–20	-8.27 ± 4.62	-8.01 ± 6.84	-9.18 ± 5.18			
0–42	-11.04 ± 6.52	-10.37 ± 8.65	-10.73 ± 5.63			
Body fat (%) by week						
0	41.46 ± 4.72	41.33 ± 5.55	39.72 ± 4.34			
4	40.09 ± 4.46	39.88 ± 5.23	38.51 ± 4.65			
8	38.36 ± 4.04	37.88 ± 4.44	36.99 ± 4.66	$p = 0.423$ [c]	$p < 0.001$ [d]	$p = 0.432$ [e]
20	36.98 ± 4.34	36.26 ± 5.00	34.89 ± 4.93			
42	35.43 ± 5.08	34.76 ± 4.59	33.68 ± 5.17			
Body fat changes (%) by week intervals						
0–4	-1.37 ±1.25	-1.45 ± 1.93	-1.21 ± 2.18			
0–8	-3.20 ± 5.62	-3.45 ± 3.20	-2.73 ± 2.50			
0–20	-4.48 ± 2.55	-5.07 ± 3.44	-4.83 ± 2.70			
0–42	-6.03 ± 3.76	-6.57 ± 4.20	-6.04 ± 4.07			

Abbreviations: * $p < 0.05$ ** $p < 0.01$ [significantly different to the group III (30%/70%) CR] (univariate ANOVA); [a] $p < 0.05$ [b] $p < 0.01$ [Comparison of baseline characteristics at week 0 among groups (one-way ANOVA)]. Comparison of different CR treatments (repeated ANOVA) [d] Comparison of changes over time among groups from week 0, to 4, 8, 20 and 42 (repeated ANOVA)
[e] Comparison of treatment effect among groups for the changes from week 0, to 4, 8, 20 and 42 (repeated ANOVA).
BMI – body mass index; WC – waist circumference.

decreased significantly by 3.95 kg/m^2 in the group I (20% CR), by 4.44 kg/m^2 in the group II (50% CR), and by 4.79 kg/m^2 in the group III (70%/30% CR). After 42 weeks, total cholesterol decreased by 7% (change -0.35 mmol/L) in the group I (20% CR) and by 8% (change – 0.43 mmol/L) in the group III (70%/30% CR) compared to baseline. LDL-cholesterol decreased by 14% (change -0.47 mmol/L) in the group I (20% CR) and by 13% (change -0.42 mmol/L) in the group III (70%/30% CR) compared to the baseline levels (Table 2). There was no significant changes in the total and LDL-cholesterol serum levels during the study period in the group II (50% CR). However, after 42 weeks the serum HDL-cholesterol level decreased significantly ($p < 0.049$) only in the group I (20% CR) while the 70%/30% CR diet had no effects on serum HDL-cholesterol levels in our study participants. Atherogenic index presented as TG/HDL ratio was significantly decreased by 0.22 ± 0.23 in the group I (20% CR), by 0.22 ± 0.29 in the group II (50% CR), and by 0.32 ± 0.28 in the group III (70%/30% CR).

Table 2 shows that after 42 weeks the level of the serum HDL-cholesterol increased significantly by 0.07 mmol/L, serum triglycerides levels decreased by 0.25 mmol/L, total and LDL-cholesterol decreased by 0.35 mmol/L and 0.47 mmol/L respectively, plasma levels of fasting glucose decreased by 0.12 mmol/L, concentration of $HbA1_C$ decreased by 0.25% and hs-CRP levels decreased by 2.22 mg/L in the moderate caloric restriction diet group (the group I). Repeated ANOVA showed significant differences in the serum total and LDL-cholesterol levels from baseline to the end of the study when compared treatment effect among CR groups (effect: time x CR group: $p < 0.025$ and $p < 0.024$, respectively). The diet with 20% energy deficit had no significant effect on total and LDL-cholesterol levels in the serum but only in this diet group fasting glucose levels decreased significantly (different treatment: $p < 0.012$). Also, this diet group had the greatest reduction in $HbA1_C$ by 0.45% considering the baseline levels, compared to other two CR groups according to the treatment duration (time 0–42 weeks: $p < 0.001$). The highest decrease in triglycerides (0.38 mmol/L) and smaller reduction in levels of fasting glucose (0.09 mmol/L) was in the diet group III with 70%/30% alternating daily CR. HDL-cholesterol concentration in this diet group, firstly decreased during 20 weeks and returned at baseline levels at the end of the study (different treatment: $p = 0.049$). However, after 42 weeks, hs-CRP decreased by 36% and 38% in the group I and the group II (time 0–42 weeks: $p = 0.001$), and by 48% in the group III compared to baseline values, despite that hs-CRP in the group III was statistically lower than in other groups at baseline (different treatment: $p = 0.048$).

Discussion

Our dietary intervention demonstrated that overweight and obese female, consuming different CR diets had the similar body weight reduction by 5% after 4 weeks of the treatment and improved cardiometabolic risk factors. Generally, different CR diet groups achieved 12% (~11 kg) weight loss at 42 weeks of the treatment from initial body weight. When we analyzed WC and percentage of body fat as outcome variables, there were no differences in the effectiveness among the different CR weight-loss methods. Participants in different CR (20%, 50%, 70%/30%) groups during long-term protocol (42 weeks) with overall weight lost by 12%, had similar reduction in WC (11–12cm) and % of body fat (15–16%). These findings indicate that different CR diets have the same effect in reducing body weight and fat mass in overweight and obese women. Our results are consistent with the evidence that most short-term dietary interventions (8–24 weeks) produce body weight decreases of 3–10%, while longer-term protocols (25–52 weeks) produce weight reductions of 10–15% [6–8, 12–14, 19–20].

It is well known that dietary interventions are effective for weight loss [7, 21]. In overweight subjects when BMI is 25–29.9 kg/m^2, advice is to introduce CR, physical activity and lifestyle modification. Tokunaga and Furubayashi [22] suggested that the diets containing 1000–1200 kcal/day should be selected for obese patients. There was some evidence that CR diets lead to clinically significant weight loss regardless of which macronutrients stand out [23]. In this research, our participants had different CR diets (20%, 50% and 70%/30% CR), but with the same macronutrient content: carbohydrate (55–60% of total calories) proteins (15–20% of total calories) and fat (less than 30% of energy intake). Very LCDs with 600 kcal/day should not be used routinely for weight-loss therapy because it requires special monitoring and supplementation. So, in the diet group III we combined alternating daily CR; on the first day very LCD of 70% and on the second day moderate LCD with 30% CR of baseline energy requirements.

No dose-response link between greater degree of CR and larger amounts of weight loss was presented in scientific works. For example, 6% reduction from baseline values during 12–13 weeks of the procedure was shown with 16% and 23% CR diets [24, 25]. Our results are consistent with the statement that a degree of CR is not a crucial factor which affects the outcome of weight loss. There was some evidence that short-term diet (4–12 weeks) made significant reductions in body fat of 10–20%. Moderate-term trials (13–24 weeks) showed similar result, 11–34% in reduction of body fat from baseline [24–28].

Visceral obesity is closely related with greater risk of cardiovascular disease (CVD) and type 2 diabetes [29, 30]. For example, in the studies with 6–8% weight loss visceral fat mass was reduced by 6–13% from baseline [6, 30]. In our study with 12% weight loss (~11kg), WC was reduced by 11 cm (15% from baseline). These changes are important since WC is an important predictor for cardiometabolic risk and metabolic syndrome [6, 17].

Reductions in body weight are generally accompanied by favorable changes in metabolic disease risk parameters. It has been presented that loss of 5%–10% of the initial body weight is a sufficient to perform clinically evident improvement of the metabolic profile of obese persons [30–33]. Published studies suggest that, for instance, weight loss of 5–15% results in fairly consistent decreases in the serum of

Table 2

Cardiometabolic risk factors before and after 20 and 42 weeks of consummation of different calorie restrictive (CR) diets

Cardiometabolic risk factors	Group I – 20% CR (n = 37) x̄ ± SD	Group II – 50% CR (n = 30) x̄ ± SD	Group III – 70%/30% CR (n = 30) x̄ ± SD	Different treatment[c] (probability)	Time interval 0–42weaks[d] (probability)	Effect Time x CR group[e] (probability)
Trigliceride (mmol/L)						
week 0	1.07 ± 0.46	1.21 ± 0.57	1.20 ± 0.98			
week 20	0.85 ± 0.96	1.08 ± 0.45	0.98 ± 0.76			
week 42	0.82 ± 0.40	0.87 ± 0.45	0.82 ± 0.38	$p = 0.893^{c}$	$p < 0.014^{d}$	$p = 0.727^{e}$
Change 0–20	-0.22 ± 0.40	-0.13 ± 0.59	-0.22 ± 0.65			
Change 0–42	-0.25 ± 0.53	-0.34 ± 0.67	-0.38 ± 0.80			
Total cholesterol (mmol/L)						
week 0	5.05 ± 1.04	5.03 ± 0.92	5.13 ± 1.06			
week 20	4.68 ± 1.02	4.95 ± 1.00	4.84 ± 1.02*			
week 45	4.70 ± 0.6	5.00 ± 1.05*	4.70 ± 0.95	$p = 0.664^{c}$	$p < 0.001^{d}$	$p = 0.025^{e}$
Change 0–20	-0.37 ± 0.51	-0.07 ± 0.40[b]	-0.27 ± 0.36			
Change 0–42	-0.35 ± 0.50	-0.35 ± 0.55[b]	-0.43 ± 0.51			
LDL cholesterol (mmol/L)						
week 0	3.35 ± 0.81	3.31 ± 0.86	3.24 ± 0.86			
week 20	2.93 ± 0.89	3.30 ± 1.01	3.03 ±0.85			
week 42	2.87 ± 0.87	3.35 ± 1.00[b]	2.82 ± 0.77	$p = 0.412^{c}$	$p < 0.02^{d}$	$p = 0.024^{e}$
Change 0–20	-0.41 ± 0.64	-0.01 ± 0.40[b]	-0.21 ± 0.36			
Change 0–42	-0.47 ± 0.51	0.04 ± 0.67[b]	-0.42 ± 0.67			
HDL cholesterol (mmol/L)						
week 0	1.46 ± 0.23	1.44 ± 0.26	1.34 ± 0.29			
week 20	1.50 ± 0.31[a]	1.53 ± 0.33[a]	1.29 ± 0.26			
week 45	1.52 ± 0.25	1.47 ± 0.31	1.34 ± 0.28	$p = 0.049^{c}$	$p = 0.654^{d}$	$p = 0.482^{e}$
Change 0–20	0.04 ± 0.31	0.04 ± 0.31	0.04 ± 0.31			
Change 0–42	0.07 ± 0.47[a]	0.03 ± 0.48	0.00 ± 0.29			
TG/HDL-cholesterol ratio						
week 0	0.79 ± 0.34	0.87 ± 0.45	0.92 ± 0.74			
week 20	0.66 ± 0.35	0.76 ± 0.44	0.76 ± 0.29			
week 45	0.58 ± 0.32	0.62 ± 0.38	0.60 ± 0.34	$p = 0.431^{c}$	$p < 0.001^{d}$	$p = 810^{e}$
Change 0–20	-0.13 ± 0.24	-0.13 ± 0.24	-0.13 ± 0.24			
Change 0–42	-0.22 ± 0.23	-0.25 ± 0.39	-0.32 ± 0.28			
Glucose (mmol/L)						
week 0	4.91± 0.44*	4.67 ± 0.65	4.57 ± 0.65			
week 20	4.82 ± 0.46	4.69 ±0.62	4.59 ± 0.33			
week 45	4.79 ± 0.45	4.50 ± 0.44	4.48 ± 0.34	$p = 0.012^{c}$	$p = 0.321^{d}$	$p = 0.113^{e}$
Change 0–20	-0.08 ± 0.45[a]	-0.08 ± 0.45[a]	-0.08 ± 0.45[a]			
Change 0–42	-0.12 ± 0.55	-0.17 ± 0.73[a]	-0.09 ± 0.55			
$HbA1_C$ (%)						
week 0	5.53 ±0.41	5.68 ±0.48	5.41 ± 0.27			
week 20	5.33 ± 0.34	5.36 ±0.90	5.31 ± 0.28			
week 42	5.27 ± 0.29	5.22 ± 0.54	5.06 ± 0.51	$p = 0.267^{c}$	$p < 0.001^{d}$	$p = 0.2.38^{e}$
Change 0–20	-0.19 ± 0.24	-0.19 ± 0.24	-0.19 ± 0.24			
Change 0–42	-0.25 ± 0.89	-0.45 ± 0.82[a]	-0.35 ± 0..8			
hs-CRP (mg/L)						
week 0	6.23 ± 2.25**	5. 75 ± 3.50**	4.75 ± 1.86			
week 20	4.88 ± 3.01[a]	4.30 ± 3.33	3.67 ± 1.91*			
week 42	4.01 ± 2.11	3.64 ± 2.19	2.46 ± 1.05*	$p = 0.048^{c}$	$p < 0.001^{d}$	$p = 0.113^{e}$
Change 0–20	-1.35 ± 2.61[a]	-1.35 ± 2.61[a]	-1.35 ± 2.61[a]			
Change 0–42	-2.22 ± 2.45	-2.11± 2.83	-2.29 ± 3.15			

Abbreviations: * $p < 0.05$, ** $p < 0.05$ [significantly different to the group III – 30%/70% CR (univariate ANOVA)].

[a] $p < 0.05$ [b] $p < 0.01$ [comparison of baseline characteristics at week 0 (one way ANOVA)].

[c] Comparison of effects of different CR treatments (repeated ANOVA).

[d] Comparison of changes over time among different CR groups [from weeks 0, to week 20 and 42 (repeated ANOVA)].

[e] Comparison of treatment effect among different CR groups [for the changes from week 0, to week 4, 8, 20 and 42 (repeated ANOVA)].

LDL – low density lipoprotein; HDL – low density lipoprotein; TG – triglycerides; HbA1 – glycosylated hemoglobin; hs-CRP – high sensivity C-reactive protein.

total cholesterol (5–20%), LDL cholesterol (5–20%), fasting glucose (5–10%), and insulin (10–40%) levels [6–9, 12–14, 16, 17, 19].

In our study, reductions in cardiometabolic risk factors were noticed in all CR diet groups. Less decrease of triglycerides levels (23%) was in the diet group I (20% CR) compared with another two groups, the group II (50% CR) and the group III (70%/30% CR) (28% and 31%, respectively). In our study, 50% CR intake had no effect on total and LDL-cholesterol serum levels in overweight and obese females regardless of the decrease of 12% in body weight. There was some evidence that plasma lipid concentrations (total cholesterol, LDL cholesterol and TG) had a tendency to decline after loss of 5% of body weight [34–36].

Previous studies in overweight and obese patients with diabetes type 2, indicated that modest weight loss of 5–10% from initial body weight markedly improve glycemic control and CVD risk factors after one year [37, 38]. In our study in overweight and obese non diabetic females with 12% reductions of initial weight during 42 weeks, different CR diet decreased fasting glucose levels (2–10%) and HbA1c (5–8%) from baseline levels with greater reduction in glucose levels (10%) in the group I (moderate 20% CR diet), although, $HbA1_c$% had better response with 50% CR (the group II) (change – 0.45 ± 0.82%) compared to the 20% CR diet group (change – 0.25 ± 0.89%). This is a worse response in non-diabetic obese or overweight females compared to evidence that in overweight or obese subjects with diabetes type 2 HbA1c has a tendency to decline (0.4%) after body weight loss of 5% [39]. Participants in the group III with combined alternating daily 70%/30% CR diet had low response to glucose levels reduction (only 2%).

However, no statistically significantly different changes in triglyceride and HDL-cholesterol concentrations, glucose levels and $HbA1_c$ and TG/HDL ratio among different CR diet groups were observed following long-term protocols of 42 weeks in our study. Interestingly, data from the Diet, Obesity, and Genes (DiOGenes) Study, first demonstrated that LCDs induced 8% weight loss in obese adults during treatment period of 8 weeks. Besides, this study showed that consuming one of the four diets with no caloric restriction, different in protein content or food glycemic index during 26 weeks, had similar effects on the serum lipid status and fasting glucose levels [39]. Some studies have shown that macronutrient composition of CR can change the blood lipid profile response to weight loss [40–42]. Recent papers have suggested that atherogenic index (TG/HDL-cholesterol ratio) is most useful for the discrimination of insulin resistance in individuals [43–45]. Our study showed that 12% reduction in body composition can induce decline (28–35%) in this biomarker of the disease risk in overweight and obese females.

CRP is an sensitive inflammatory marker [45, 46], whose values fall in the blood after loss of 10% of initial body weight [47]. Marked weight loss has also been found to reduce the concentration of hs-CRP [48, 49]. Significant reduction in body weight decreases the concentration of hs-CRP. In our study, 12% reduction in body weight produced potent reduction (35–48%) in hs-CRP levels. In a recent meta-analysis of 33 weight loss intervention studies, conclusion was that there was a strong correlation between declines in body weight and the hs–CRP levels. Also, this study supported possibility to reduce the hs–CRP levels by non-pharmacological method such as an ordinary weight reduction [50]. It is interesting that despite lower basal levels of hs-CRP in the diet group III compared to another two CR diet groups alternating daily CR of 70% and 30% showed higher reduction of hs-CRP (48% from baseline) compared with 20% and 50% CR diets. These effects are essential for reduction in the CVD risk because hs-CRP is CVD predictor and an inflammatory molecule accumulated in the atherosclerotic process [46]. DiOGenes study showed that hs–CRP could be, even more reduced by a diet with a low glycemic index and significantly less content of proteins [41].

This study has limitation because we did not divide our study population into two subgroups (overweight and obese women) and compare the effects of different CR diets between them. The reason for this is high dropout rate (60%) that may limit the use of the study results in public health programs.

Conclusion

Different caloric restriction diets with the same macronutrient content have the same effect in decreasing body weight and body fat, as well as similar effect in reduction of cardiometabolic risk factors in overweight and obese females. In addition, this study confirmed that reduced body weight have beneficial effect on reducing level of pro-inflamatory hs-CRP.

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