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The decrease in C-reactive protein concentration after diet and physical activity induced weight reduction is associated with changes in plasma lipids, but not interleukin-6 or adiponectin

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Abstract

Subclinical inflammation is a risk factor for cardiovascular disease. The mechanisms underlying increased levels of inflammatory markers and their changes in response to weight loss are not fully understood yet. It has been proposed that elevated concentrations of C-reactive protein (CRP) are mediated by cytokines produced in adipose tissue. We investigated the changes in circulating CRP after weight reduction, in relation to parameters relevant to the metabolic syndrome. Forty 25- to 35-year-old obese female volunteers participated in an intervention program of dietary education and supervised physical activity for a period of 9 weeks. Anthropological parameters and biochemical measurements (high-sensitivity CRP [hsCRP], plasma lipoproteins, interleukin 6 [IL-6], adiponectin) were analyzed before and after the intervention. Body mass index decreased by more than 7% from 31.5 ± 4.1 to 29.1 ± 3.9. Plasma free fatty acid (FFA) concentrations decreased by 30%, high-density lipoprotein cholesterol increased by 8%, and fasting insulin concentrations decreased by 15%. There were no significant changes in either low-density lipoprotein cholesterol or triacylglycerol concentrations. Subcutaneous and visceral adipose tissue mass decreased by 12% and 18%. High-sensitivity CRP concentrations decreased by 30%; however, mean plasma IL-6 and adiponectin concentrations remained unchanged. In linear regression analysis, the changes in plasma hsCRP concentrations were associated with baseline hsCRP concentration, change in triacylglycerols and FFA concentrations, and in waist circumference. The decrease in hsCRP concentration after weight reduction does not appear to be mediated by decreases in circulating IL-6 or adiponectin concentrations; however, change in hsCRP concentration is related to changes in waist circumference and lipid metabolism, reflected by plasma triacylglycerol and FFA levels.

1. Introduction

Lipoprotein abnormalities, hypertension, and insulin resistance (associated with the metabolic syndrome) are important and highly prevalent risk factors for the development of premature coronary heart disease [1]. However, there is mounting evidence implicating a heightened immune response and inflammation in the initiation and progression of the atherosclerotic disease, as has been suggested by Ross [2]. Moderate increases in circulating levels of C-reactive protein (CRP) within nonpathological "reference" range, detected with high-sensitivity methods (high-sensitivity CRP [hsCRP]), have been documented to be a sensitive marker of subclinical inflammation (ie, proinflammatory state) [3]. During the last few years, several studies have associated moderate elevation of this immediate-phase protein with an increased risk of coronary heart disease [4,5]. Elevated hsCRP concentrations are associated with obesity [6], insulin resistance [6,7], and

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metabolic syndrome [8], and decrease after weight reduction [9-14]. In addition, hsCRP appears to be a sensitive indicator of endothelial dysfunction (now widely recognized as an early event in atherogenesis) and is also correlated with urinary albumin excretion, suggesting a link to renal vascular pathology [14].

It has been proposed that atherosclerosis and type 2 diabetes mellitus probably share a common inflammatory basis, as suggested by known relationship between parameters related to insulin resistance and hsCRP concentrations [15]. Cytokines produced by monocytes and macrophages in the subendothelium of atherosclerotic lesions or by adipocytes are believed to stimulate hsCRP production. Recent evidence suggests that obesity per se can directly affect the progression of coronary atherosclerosis in young men [16], supporting again an inflammatory basis for atherosclerosis progression observed in obesity. It has been proposed that immediate-phase reactants, predominantly characterized by interleukin-6 (IL-6), promote hsCRP production by the liver as a component of the subclinical inflammation related to obesity.

In the present study, we examined changes in the proinflammatory status of young obese women, assessed by circulating concentrations of hsCRP, in relation to the lipoprotein concentrations, insulin resistance, circulating IL-6 and adiponectin concentrations, and anthropometric parameters (including adipose tissue volume) after a lifestyle intervention consisting of dietary education and exercise intervention intended to achieve weight reduction.

2. Research design and methods

2.1. Subjects and study protocol

A group of 40 young obese female volunteers recruited via an advertisement on a lifestyle web site and in women's journal underwent a 9-week course of lifestyle intervention. The inclusion criteria were 25 to 35 years of age and body mass index (BMI) of more than 29 kg/m^2. Exclusion criteria were known inflammatory or metabolic diseases (diabetes, thyroid gland disease, any other endocrine disorders, autoimmune diseases, any chronic inflammation, or neoplastic disease). The intervention consisted of dietary education (comprising a weekly supervised dietary record) combined with increase in physical activity. Dietary education was aimed at lowering energy intake, together with decrease in animal fat intake. Eating more fruits and vegetables was also encouraged. The volunteers participated 3 times weekly in a supervised 1-hour training session at a fitness center, and 3 more sessions per week of cycling, jogging, or brisk walking. All these activities included an aerobic exercise component—the participants were supervised (and advised) to sustain heart rate of 130 to 135 beats per minute for 45 minutes within 60 minutes of exercise. The details of intervention have been published elsewhere [17].

The women received a physical examination at baseline and after the intervention. The subjects completed questionnaires assessing health and lifestyle activities. Measurements included height, weight, waist, hips, body composition (magnetic resonance imaging [MRI] scan for subcutaneous and visceral fat volume), heart rate, blood pressure, and collection of blood samples for determination of lipoprotein, free fatty acid (FFA), insulin, glucose, hsCRP, IL-6, and adiponectin concentrations. Before enrolling in the study, written consent was obtained from each subject. The informed consent form and the study protocol were approved by the Ethics Committee of the Institute for Clinical and Experimental Medicine.

2.2. Assays, MRI, and data analysis

Plasma triacylglycerol levels, and total, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) concentrations were measured enzymatically by a standardized procedure (Centers for Disease Control and Prevention external quality control system), using Cobas Mira analyzer (Hoffman-LaRoche). High-sensitivity CRP concentration was measured by an ultrasensitive assay from Orion-Diagnostica. Very low-density lipoprotein cholesterol (VLDL-C) and VLDL-triacylglycerol concentrations were measured after ultracentrifugation at the separated fraction of VLDL. Free fatty acid concentrations were analyzed by colorimetric method [18]. The measurement of IL-6 concentration was performed with an immunoradiometric assay (IRMA) assay from Biosource (California; distributed by Eurorad Ltd, Praha, Czech Republic). The insulin concentrations were determined using an IRMA assay of Immunotech (Prague, Czech Republic). Adiponectin was measured in samples available from 27 subjects with a radioimmunoassay for human adiponectin (Linco Research, St Charles, MO).

Measurements of visceral and subcutaneous fat volumes were obtained from 28 of the 40 subjects enrolled in the study by an MRI, using Siemens (Germany) Vision 1.5-T scanner. Twenty-one continuous axial slices covered the section of abdomen 10 cm above and below the umbilicus. Segmentation of the fat volume was performed using our homebuilt software application written in PV-WAVE (Visual Numerics). An automatic procedure for finding the threshold of the fat signal using a histogram evaluation of the complete volume was developed, and the volume of fat tissue was calculated after manual delineating of the fat volume by 2 independent observers [19].

Statistical analyses were performed using R statistical software (www.r-project.org). Pairwise associations between the target variables were assessed using the Pearson correlation coefficient. Multiple linear regression was used to explain observed pairwise differences in hsCRP concentrations (postintervention minus baseline values or ΔhsCRP). Simple regression models may not reveal existing associations between the predictors and the response variable because of confounding, as was the case in this

Table 1
Characteristics of the women at the baseline and after intervention (mean ± SD)

N = 40	Baseline	After intervention	*P*	%Δ
Weight (kg)	88.56 ± 12.51	81.75 ± 11.95	<.001	−7.7 ± 2.4
BMI (kg/m^2)	31.52 ± 4.08	29.09 ± 3.89	<.001	−7.7 ± 2.4
Waist circumference (cm)	93.2 ± 10.3	85.5 ± 9.1	<.001	−8.2 ± 3.6
Hip circumference (cm)	114.3 ± 8.0	106.3 ± 8.8	<.001	−7.0 ± 3.2
Waist-hip ratio	0.82 ± 0.06	0.80 ± 0.06	.163	−1.2 ± 5.2
Systolic blood pressure (mm Hg)	127.6 ± 9.0	119.7 ± 9.9	<.001	−6.4 ± 6.9
Diastolic blood pressure (mm Hg)	81.0 ± 7.4	76.7 ± 7.7	.001	−4.9 ± 9.5
Heart rate (beats per min)	81 ± 8	79 ± 7	.143	−1.7 ± 8.7
Subcutaneous fat (cm^3) (n = 28)	706 ± 164	624 ± 170	<.001	−12.3 ± 9.2
Visceral fat (cm^3) (n = 28)	1667 ± 801	1375 ± 6860	<.001	−18.5 ± 11.5
Visceral-subcutaneous ratio	2.35 ± 0.18	2.18 ± 0.17	<.001	−7.1 ± 8.5
Total cholesterol (mmol/L)	5.26 ± 0.82	5.31 ± 0.85	.595	1.6 ± 11.6
Triacylglycerols (mmol/L)	1.20 ± 0.50	1.24 ± 0.50	.516	11.4 ± 43.0
LDL-C (mmol/L)	3.06 ± 0.71	3.01 ± 0.74	.462	−1.1 ± 14.1
HDL-C (mmol/L)	1.53 ± 0.34	1.62 ± 0.39	<.05	7.8 ± 21.7
FFA (mmol/L) (n = 39)	0.86 ± 0.31	0.57 ± 0.19	<.001	−30.9 ± 31.7
VLDL-triacylglycerols (mmol/L) (n = 33)	0.610 ± 0.456	0.609 ± 0.431	.982	9.0 ± 75.6
VLDL-C (mmol/L) (n = 33)	0.264 ± 0.175	0.278 ± 0.168	.718	5.3 ± 71.6
Glucose (mmol/L)	5.21 ± 0.43	5.32 ± 0.34	.094	2.5 ± 7.7
Insulin (μIU/mL)	10.1 ± 4.9	8.6 ± 4.2	<.01	−6.8 ± 41.6
HOMA index	2.33 ± 1.13	2.04 ± 1.01	.090	3.0 ± 46.9
hsCRP (mg/L)	4.31 ± 3.71	3.01 ± 3.12	.0002	−30.1 ± 39.1
IL-6 (pg/L) (n = 33)	9.01 ± 6.47	11.25 ± 7.21	.249	35.0 ± 81.4
Adiponectin (μg/mL) (n = 27)	7.9 ± 2.6	7.5 ± 2.9	.64	−3.6 ± 19.3

The statistical significance is based on the paired *t* test. WHR indicates waist-hip ratio.

analysis. The effects of covariates such as the change in FFA concentration, the change in waist circumference, or the change in triacylglycerol values were in this analysis confounded by the effect of the strongest predictor, the initial values of hsCRP. When adjusted for the effect of initial values of hsCRP on the observed differences in hsCRP, an independent effect of other covariates may be properly assessed. The associations indicated by the multiple regression model could not have been identified using simple regression model (or correlations). Thus, a major issue in this analysis was the need to adjust for the effect of initial hsCRP concentrations.

To further test the validity of the results of our linear regression analysis, additional analyses were performed to exclude possible bias caused by outlier values. In the first additional analysis, all women with an increase in hsCRP concentration (n = 3) were excluded, and in the second analysis, all women with extreme hsCRP were dropped (n = 3). Finally, both of these extremes were excluded. Nevertheless, the results of the linear regression analysis as shown in Table 2 were stable in all these additional analyses, without any change in the trends.

3. Results

3.1. Body composition and blood pressure

Mean weight loss during the intervention period was 6.8 ± 0.4 kg (range, 2.6-12.0 kg) for approximately 7.7% ± 0.4% (range, −3.1% to −12.1%) of baseline body weight (Table 1). Waist circumference decreased by 8% and hip circumference by 7%, but the waist-hip ratio was unaltered during the intervention. Subcutaneous abdominal fat volume decreased by 12% and visceral fat volume by 18%. The ratio of visceral to subcutaneous fat decreased by ~7% after the intervention period (Table 1). Visceral fat volume at baseline was positively correlated with BMI (r = 0.58, P = .0013), waist-hip ratio (r = 0.54, P = .0028), and hsCRP (r = 0.39, P = .043), and inversely with HDL levels (r = 0.54, P = .003). The decrease in waist circumference correlated with the change in visceral fat volume (r = 0.57, P < .005), but not with the change in subcutaneous fat volume (r = 0.11, P = .60). Detailed results of the changes in body composition have been published previously [17].

Significant decreases in both systolic and diastolic blood pressures were noted. No change in resting heart rate was observed during the study. There was no significant correlation between the changes in blood pressure and decreases in body weight.

3.2. Lipids, glucose, and insulin

Measurements obtained at the baseline and after the intervention are presented in Table 1. Serum concentrations of total and LDL-C were within reference ranges at baseline and did not change significantly after the intervention. High-density lipoprotein cholesterol increased significantly, and plasma FFA concentrations decreased by 30% from 0.86 ± 0.31 to 0.57 ± 0.19 mmol/L (P < .0001). There was no significant change in triacylglycerol concentration. Fasting insulin concentrations at baseline were positively correlated

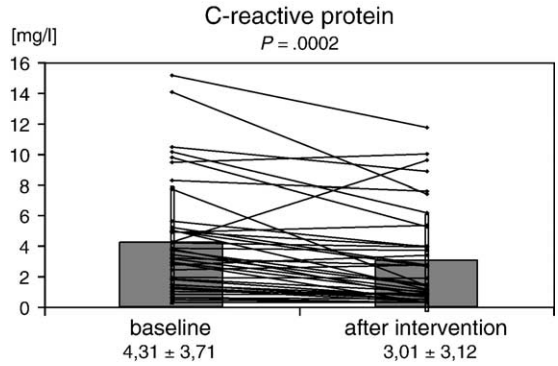

Fig. 1. High-sensitivity CRP concentration at the baseline and after intervention (individual changes shown as black lines).

with FFA concentration (r = 0.48, P = .011). Fasting plasma insulin levels decreased from 10.08 ± 4.85 to 8.57 ± 4.19 μU/mL (P = .02), suggesting increased insulin sensitivity. However, fasting plasma glucose levels, which were within reference range at baseline, did not change during the intervention period, and the decrease in the homeostasis model assessment (HOMA) index of insulin resistance was not statistically significant.

3.3. High-sensitivity CRP, IL-6, and adiponectin

A 30% reduction in plasma hsCRP concentrations was one of the most prominent outcomes of the lifestyle intervention (Fig. 1), decreasing from 4.31 ± 3.71 to 3.01 ± 3.12 mg/L (double P = .0002). The medians were 3.35 (interquartile range, 1.47/5.17) at the baseline and 1.46 (interquartile range, 0.7/3.99) after intervention. The median of hsCRP change was −0.86 (interquartile range, −2.33/−0.13). A decrease in hsCRP concentration was observed in all but 4 women (Fig. 1). Mild infection was documented in 2 of these 4 subjects afterward. In contrast, plasma IL-6 concentrations did not change during the intervention period: baseline, 9.01 ± 6.47; after intervention, 11.25 ± 7.21 pg/L (P = .249) (Fig. 2). Adiponectin levels did not increase after the intervention.

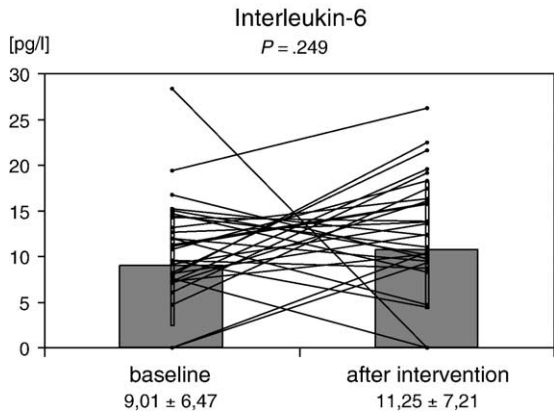

Fig. 2. Interleukin 6 concentration at the baseline and after intervention (individual changes shown as black lines).

Table 2
Analysis of variance for hsCRP difference (final − baseline values)

Parameter	*df*	Mean square	*P* (>F)
Baseline hsCRP	1	42.63	<.0001
Waist difference	1	7.854	.0026
FFA difference	1	7.205	.0037
Triacylglycerol difference	1	18.376	<.0001
Baseline hsCRP * waist difference	1	14.021	.0001
Residuals	30	0.726	–

Mean squares indicate the proportion of (total or explained) variance corresponding to each predictor in the linear regression model.

3.4. Correlations

Baseline hsCRP concentrations were positively correlated with baseline BMI (r = 0.36, P = .02), visceral (r = 0.51, P = .0059) and subcutaneous (r = 0.42, P = .028) fat volumes, and waist circumference (r = 0.44, P = .0046). High-sensitivity CRP concentration after intervention was correlated with final BMI (r = 0.42, P = .0064), waist circumference (r = 0.41, P = .0091), triacylglycerol concentration (r = 0.37, P = P = .019), visceral (r = 0.50, P = .0069) and subcutaneous (r = 0.497, P = .0072) fat volumes, hip circumference (r = 0.37, P = .019), fasting insulin (r = 0.36, P = .021), and HOMA index (r = 0.35, P = .029). Other correlations for baseline and final hsCRP concentration or its change were not statistically significant. Visceral fat mass at baseline was inversely related to plasma HDL levels (r = −0.54, P = .003).

At baseline, plasma adiponectin concentrations were negatively correlated with BMI (r = 0.42, P = .025) and highly positively correlated with HDL levels (r = 0.65, P = .0002). High-sensitivity CRP tended to be inversely related to adiponectin levels (r = 0.36, P = .065). As discussed, adiponectin did not increase during the intervention, and changes in adiponectin were not related to the changes in BMI, HDL, or hsCRP levels.

The following variables were included in the linear regression analysis: all the parameters shown in Table 1, except for visceral and subcutaneous fat volumes and adiponectin levels (because the measurements were available only for 28 of our 40 subjects), plus scored physical activity and adherence to diet. The changes in hsCRP concentrations were significantly correlated with 5 parameters: hsCRP at baseline (P < .001), the change in waist circumference (P = .0026), the change in FFA concentrations (P = .0037), the change in triacylglycerol levels (P < .001), and combined parameter of baseline hsCRP concentrations and waist difference (P < .001). According to the estimates of influence, a 1 mmol/L reduction in triacylglycerol concentration resulted in an average reduction in hsCRP concentration of 1.53 mg/L.

According to the mean squares in analysis of variance (Table 2), 47.3% of the total explained variability in the changes in hsCRP during the intervention was attributed to baseline concentrations of hsCRP. Another 20.4% was mediated by change in triacylglycerol concentration,

whereas changes in waist circumference and FFA concentrations mediated additional 8.7% and 8.0% of the hsCRP concentration differences, respectively. An interactive term of baseline hsCRP and the change in waist circumference mediated the remaining 15.6% of the total explained variability in hsCRP change. This multiplicative term expresses the fact that the magnitude of hsCRP reduction may be different with the same decrease in waist circumference, depending on the baseline hsCRP. The total variability left unexplained by the model, as described by the corresponding mean square, was only 0.726 on 30 *df*.

4. Discussion

A substantial decrease in weight and body adiposity was achieved in women during the 9-week intervention by a combination of dietary changes and increased physical activity. Because the women in the present study were well aware of the composition of a healthy diet before entering the study, only minor dietary changes were made to reach an optimal dietary composition in most subjects. However, restriction of energy intake was emphasized because average energy intake of the subjects before the study was estimated to be approximately 25% higher than the recommended daily allowance according to the age and physical activity. Most previous studies, examining the effects of weight loss on proinflammatory status in obese individuals, used dietary intervention only (or other means to decrease energy intake, eg, gastric banding).

As would be expected, the amount of the body weight lost depended on the adherence to the dietary regimen and physical activity program—these results have been previously published elsewhere [17]. The duration of our study was shorter than in other studies, but with more intensive regimen, documented by a highly significant decrease in body weight of 6.8 kg in 9 weeks, compared with weight loss of 14 kg within 2 years in the study by Esposito and colleagues [12].

Average baseline total cholesterol, LDL-C, and triacylglycerol concentrations were already within reference ranges, and minor dietary changes did not result in a further lowering. A highly significant 30% reduction of plasma FFA levels was observed, likely induced by increased physical activity [20]. Increase in HDL-C concentration can also be ascribed to the increase in physical activity, a result similar to that reported by Rennie et al [21], in whose study a relatively short (9 weeks) exercise intervention was sufficient to produce statistically significant increase in HDL-C.

Fasting plasma insulin concentrations decreased significantly. Increases in insulin sensitivity after weight reduction have been documented in many other studies [22]. The significant decrease in blood pressure is likely a combined result of improvement of physical fitness and decrease in body weight [23]. The beneficial metabolic effects of weight loss are likely not to be only mechanical, as has been previously proposed, but may involve a reduction of cytokines produced in adipose tissue that influence vascular reactivity [24].

A pronounced decrease in plasma hsCRP concentrations was observed. Decreases in hsCRP concentrations after weight reduction have been documented in 4 other recently published interventional studies [9,11-13]. IL-6 is a mediator of CRP production, which is produced by monocytes and macrophages in response to low-grade infection or any other inflammatory stimuli. It has been suggested that elevated nonimmediate production of hsCRP is mediated by a regulatory pathway similar to the one of immediate reaction, via IL-6. Because up to one third of circulating IL-6 is produced by adipose tissue [25], IL-6 could be an important mediator linking obesity and proinflammatory status as assessed by elevated hsCRP levels. Proinflammatory status associated with obesity may be mediated by adipocyte cytokine production. It is unlikely that the young and relatively healthy subjects included in the present study had advanced atherosclerotic lesions containing activated macrophages; it is probable that the main source of measured IL-6 is adipose tissue.

No correlation between the changes in hsCRP and IL-6 concentrations was documented in our study. Although a highly significant (30%) decrease in hsCRP concentrations was observed, IL-6 concentrations were not significantly altered. Similar results were found in the study by Laimer et al [11]. In the recent study by Klein et al [26], no change in hsCRP concentration was observed after liposuction. In contrast, in 2 other studies, IL-6 concentration decreased after weight reduction, and the decrease was correlated with change in hsCRP concentrations. The reason for this discrepancy may be in the design of the studies: different periods of follow-up and variations in the design of the weight loss protocol. In the study of Kopp et al [13], weight reduction was achieved solely by lowering of energy intake, and in the study of Esposito et al [12], the physical activity component was modest compared with intensive controlled physical training in the presented study. In our study, 2 different mechanisms were included in the intervention: lowering of energy intake and increase in intensive physical activity. Joining of these 2 components may have had an additive effect on the improvement of metabolic parameters; however, it is not possible to determine their individual contributions in a study with combined intervention. According to the report by Keller et al [27], IL-6 concentrations increase with physical activity. Thus, it is possible that the increase in physical activity also influenced IL-6 production in the present study.

Adiponectin is a large-molecular-weight adipocyte-derived hormone. Low circulating levels of adiponectin are associated with components of the metabolic syndrome, including visceral obesity, elevated triacylglycerols, low HDL, and insulin resistance [28]. Reduced circulating adiponectin levels in obese subjects have been hypothesized to be involved in the pathogenesis of atherosclerosis and

cardiovascular disease [29]. For example, adiponectin has direct protective anti-inflammatory effects on vascular endothelium [30] and protects against atherosclerosis in apolipoprotein E–deficient mice [31]. Data from large cross-sectional studies demonstrate that adiponectin levels are positively related to plasma HDL-C and insulin sensitivity, and negatively correlated with triacylglycerols and CRP, independent of sex or body adiposity [32,33].

In this study, plasma adiponectin levels did not increase after weight loss induced by the lifestyle intervention. Circulating adiponectin levels do not increase with modest weight loss induced by short-term energy-restricted diet [34] or liposuction [26]. Plasma adiponectin does increase after marked weight loss such as that induced by gastric bypass surgery [35], and the increase in adiponectin is associated with improved insulin sensitivity after weight loss [35]. It has been hypothesized that adiponectin production is regulated by adipocyte size and insulin sensitivity and that a substantial reduction of adipocyte size is required to increase adiponectin production and circulating adiponectin concentrations [28]. Therefore, the modest degree of weight reduction in the present study was insufficient to augment adiponectin production. The changes in adiponectin are unlikely to be involved in the observed anti-inflammatory response or improved insulin sensitivity. However, because available assays for adiponectin only measure the total level of the circulating protein, changes in the distribution of adiponectin complexes from low- to high-molecular-weight multimers cannot be ruled out. An increased ratio of the high-to low-molecular-weight forms of adiponectin has been implicated as an important contributor to hepatic insulin sensitivity [36].

An alternative pathway regulating inflammation and plasma hsCRP concentrations, other than IL-6 or adiponectin, is likely to exist. Results from other studies suggest that the relationship between hsCRP concentration and inflammatory cytokines is not straightforward. For example, in the study by Silvestri et al [37], plasma hsCRP concentration increased after the introduction of hormonal replacement therapy, but all other inflammatory parameters measured (eg, IL-6, adhesion molecules) were decreased. In the present study, by linear regression analysis, the change in hsCRP concentration was best described by the changes in only 3 other variables: triacylglycerol and FFA concentrations, and waist circumference. Elevated triacylglycerol concentration and abdominal obesity, along with insulin resistance and hypertension, are involved in metabolic syndrome. It has been suggested that subclinical inflammation is an additional component of the metabolic syndrome, linking obesity with insulin resistance and atherosclerosis [7]. This hypothesis is supported by the observation that baseline hsCRP concentrations are positively related to BMI, waist circumference, and visceral fat mass.

High-sensitivity CRP baseline * waist difference parameter in the linear regression analysis suggests that interindividual variability has an important influence on the results. Accordingly, the present observation indicates that different volunteers with the same decrease in waist circumference would have different decrease in hsCRP concentration. The impact is much more pronounced in subjects with higher initial values of CRP. The underlying basis for this observation is likely to be genetic: genetic polymorphisms in regulatory loci may result in a susceptibility to higher immune reactivity and elevated expression of immediate-phase related proteins, even under basal conditions (eg, in the absence of immediate proinflammatory stimuli).

5. Conclusion

Circulating concentrations of hsCRP decreased in young obese women after weight reduction achieved by an intervention designed to lower energy intake and increase physical activity. The changes in hsCRP concentration did not appear to be mediated by changes in IL-6 or adiponectin concentrations. The association between the changes in hsCRP and the changes in plasma triacylglycerols and FFA links subclinical inflammation with dysregulation of lipid metabolism in metabolic syndrome (mostly characterized by hypertriacyglycerolemia), thus suggesting that subclinical inflammation may be an integral part of metabolic syndrome.

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