Conjugated Linoleic Acid Reduces Body Fat Mass in Overweight and Obese Humans[1]

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ABSTRACT Conjugated linoleic acid (CLA) has been shown to reduce body fat mass (BFM) in animals. To investigate the dose-response relationships of conjugated linoleic acid with regard to BFM in humans, a randomized, double-blind study including 60 overweight or obese volunteers (body mass index 25–35 kg/m^2) was performed. The subjects were divided into five groups receiving placebo (9 g olive oil), 1.7, 3.4, 5.1 or 6.8 g conjugated linoleic acid per day for 12 wk, respectively. Dual-energy X-ray absorptiometry was used to measure body composition [measurements at wk 0 (baseline), 6 and 12]. Of the 60 subjects, 47 completed the study. Eight subjects withdrew from the study due to adverse events; however, no differences among treatment groups were found regarding adverse events. Repeated-measures analysis showed that a significantly higher reduction in BFM was found in the conjugated linoleic acid groups compared with the placebo group ($P = 0.03$). The reduction of body fat within the groups was significant for the 3.4 and 6.8 g CLA groups ($P = 0.05$ and $P = 0.02$, respectively). No significant differences among the groups were observed in lean body mass, body mass index, blood safety variables or blood lipids. The data suggest that conjugated linoleic acid may reduce BFM in humans and that no additional effect on BFM is achieved with doses > 3.4 g CLA/d. J. Nutr. 130: 2943–2948, 2000.

KEY WORDS: • *conjugated linoleic acid* • *body composition* • *body fat mass* • *lean body mass* • *humans*

Conjugated linoleic acid (CLA)[3] is a term used to describe positional or geometrical derivatives of linoleic acid containing conjugated double bonds. The natural source of this polyunsaturated conjugated fatty acid is microbial isomerization of dietary linoleic acid (Chin et al. 1994). CLA (mainly *cis*-9, *trans*-11 but also *trans*-10, *cis*-12 and other isomers) is readily formed in the first biohydrogenation step of linoleic acid by the action of linoleic acid isomerase of the bacterium *Butyrivibrio fibrisolvens* (Kepler et al. 1970 and 1971).

Consistent and convincing effects of CLA on body composition have been documented in several animal models, i.e., CLA has been shown to reduce body fat and to increase lean body mass (LBM) in pigs (Dugan et al. 1997), mice (Pariza et al. 1996, Park et al. 1997), rats and chicks (Pariza et al. 1996). The CLA-induced changes have been linked to increased lipolysis in adipocytes and enhanced fatty acid oxidation in both adipocytes and skeletal muscle cells (Pariza et al. 1997, Park et al. 1999b). Park et al. (1999a) showed that in mice, dietary CLA significantly increased total carnitine palmitoyltransferase activity in both fat pad and skeletal muscle, but not in the liver. In addition, hormone sensitive lipase activity was increased in adipocytes from CLA-fed mice (Pariza et al. 1997). In 3T3-L1 adipocytes, CLA reduced heparin-releasable lipoprotein lipase activity and intracellular concentration of triacylglycerol and glycerol (Park et al. 1997).

The consistent and well-documented data from both animal and in vitro studies have led to an increased interest in whether CLA exhibits the same fat-to-lean body mass repartitioning property in humans. The scope of this study was to investigate the putative beneficial effects of CLA on overweight or obese humans in relation to body fat mass (BFM), LBM, weight reductions and blood lipids.

SUBJECTS AND METHODS

Subjects. Subjects participating in the study were healthy men and women recruited after an announcement in the local newspaper at the study site. The subjects were referred to the research center (CECOR AS, Haugesund, Norway).

Inclusion criteria. All subjects were >18 y old and had a body mass index (BMI) > 25 kg/m^2 and < 35 kg/m^2. The range for BMI was chosen in accordance with the World Health Organization definition for grading overweight and obesity (WHO 1997).

Exclusion criteria. Subjects who had used drug therapy for weight loss the previous week, subjects using adrenergic stimulating medication or undergoing insulin treatment, or subjects with any unstable medical or psychiatric illness or with any clinical condition

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[3] Abbreviations used: BFM, body fat mass; BMI, body mass index; CLA, conjugated linoleic acid; DXA, dual-energy X-ray absorptiometry; LBM, lean body mass; VAS, visual analog scale.

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that rendered the subject unfit to participate were excluded from the study. In addition, pregnant lactating women were excluded.

Ethics. Approval from the Regional Ethics Committee was given before the onset of the study. Written informed consent was obtained from all participating volunteers. The study was conducted in agreement with the current version of the declaration of Helsinki.

Study design. The trial was performed as a single-center, randomized, double-blind, placebo-controlled study with five parallel groups. Precise sample size estimation was problematic due to the limited data available. Sixty subjects were allocated to two strata, men or women in the ratios of 1/3 (n = 20) and 2/3 (n = 40), respectively, and within strata randomized to placebo (9 g olive oil) or 1.7, 3.4, 5.1 or 6.8 g CLA/d. The daily dosage was divided into three doses taken at breakfast, lunch and dinner. The treatment lasted for 12 wk. To ensure the double-blinding, a double-dummy technique was used. Each subject received four boxes (marked A, B, C and D) containing either placebo or CLA capsules. The subjects took one capsule from each of the four boxes at each intake. Thus, in the highest dosage group, all boxes contained CLA capsules and in the placebo group, all boxes contained placebo capsules. The total intake was 12 capsules per day for each subject. The active capsules contained 750 mg oil of which 75% was CLA (Tonalin, Natural Lipids, Norway). The CLA preparation consisted of equal parts of the *cis*-9, *trans*-11 isomer and the *trans*-10, *cis*-12 isomer. As placebo, olive oil capsules were chosen because this oil is regarded as relatively inactive in this context. All capsules were opaque soft gel capsules of identical appearance. Both active capsules and placebo capsules were supplied by Natural Lipids, Hovdebygda, Norway.

Clinical assessment. The study required three visits to the clinic. Measurements of BFM, LBM (total mass minus both fat mass and bone mineral content), weight, blood pressure, heart rate and recording of possible confounding factors such as physical exercise were made at each visit. Blood samples for safety assessment and physical examinations were scheduled for the first and third visit. In addition, baseline characteristics and demographic data such as gender, height, smoking and alcohol consumption were recorded on the first visit. Adverse events were monitored throughout the study. For every adverse event, a rating of severity, frequency, drug relation, action taken and subject outcome was recorded. Compliance during the trial was expressed as the discrepancy between the expected number of capsules taken and the actual number of capsules used, divided by the expected number of capsules taken. Blood samples were analyzed by validated methods at a commercial clinical laboratory accredited for all tests performed (Fürst Medical Laboratory, Oslo, Norway). The following blood variables were analyzed: hemoglobin, erythrocytes, white blood cells, platelets, serum creatinine, calcium, sodium, chloride, potassium, serum creatine phosphokinase, lactate dehydrogenase, alanine transaminase, aspartate transaminase, serum ferritine, γ-glutamyl transferase, bilirubin, glucosylated hemoglobin A_{1c}, serum lipase (activity), triglycerides, total cholesterol, LDL cholesterol, HDL cholesterol and lipoprotein (a).

Measurement of body composition. Dual-energy X-ray absorptiometry (DXA) was used to measure body composition. The DXA measurement was performed with a Hologic QDR-2000, (Hologic, Waltham, MA).

Self-evaluation of quality of life. Possible treatment effects on working capacity, general vitality and some other aspects of quality of life were assessed by a quality of life questionnaire using visual analog scales (VAS) of 100 mm. The VAS registration was comprised of seven questions related to sleep, gain from training, appetite, mood, stress, working capacity and leisure activity during the last 14 d. The subjects assessed these questions twice during the study (at baseline and at 12 wk).The subjects were asked to score the different categories by putting a mark between the end points [not at all satisfied (0 mm) or completely satisfied (100 mm)]. Scores at baseline were then compared with scores after 12 wk by taking the difference between the wk 0 (baseline) and the wk 12 values for each category. This difference was used for the statistical analysis.

Physical training. The subjects received an offer by a local training center in Haugesund to follow a standard training program. The training was registered as light (without sweat) or intensive (with sweat).

Statistical analysis. Means were used for estimation of the expected value for continuously distributed variables, and are given with SD and number of subjects. Most variables, including main variables, were considered normally distributed; thus parametric methods were used for estimation and statistical significance testing. Frequency rates were used for estimation of categorical variables. Changes from wk 0 to 6 and from wk 0 to 12 within treatment groups were tested with a paired t test; however, in some cases in which a large proportion of subjects showed no change, the Sign test or Wilcoxon Rank-Sum test was used. Differences among the five treatment groups were analyzed with ANOVA test (demographic and clinical variables at inclusion), repeated-measures ANOVA (clinical variable differences between wk 0 and 6 or 12) and analysis of covariance (laboratory variables measured at wk 0 and 6 with wk 0 value as cofactor). The null hypothesis stated equal changes between treatment groups vs. at least one of the active groups different from placebo. Dunnett's test was used for testing each of the four active groups pair wise against placebo, controlling for type-I error. Categorical variables were analyzed using Fisher's exact test. A P-value $\leq$ 0.05 was regarded as significant, and all tests were performed two-sided. The statistical analyses were performed using the Statistical Analysis Systems version 6.12 (SAS Institute, Cary, NC).

Subjects with two visits or more (at least wk 0 and 6) were included in the main analysis, whereas subjects with only the wk 0 visit were not included. A few subjects missed some of the wk 6 values. For these subjects, values were interpolated by taking the mean of the wk 0 and 12 values. Last-value-carried-forward was not applied here because the number of subject visits was limited.

RESULTS

Background. The number of subjects included in the study was 60 (5 × 12 subjects). The data analyzed in the main analysis were from 52 subjects because 8 subjects withdrew during the first 6 wk of the study. There were no differences in baseline registrations of height, weight and BMI or in demographic variables such as gender, age, smoking and alcohol habits when subjects included in the main analyses were examined (**Table 1**). Moreover, demographic data and baseline characteristics of the eight subjects that withdrew were not different from the data obtained from the main analyses. Five subjects withdrew from the study between wk 6 and 12, these subjects were not included in the analyses performed for the final visit. Thus, 47 of 60 subjects completed the study. The reasons for subject withdrawals from the study were adverse events for eight subjects and five subjects did not return even after reminders (**Fig. 1**). The rates of adverse events did not differ significantly among treatment groups.

Compliance for subjects in the main analysis (52 subjects), when still present in the study, were 87, 82, 84, 85 and 88% in the 0, 1.7, 3.4, 5.1 and the 6.8 g CLA groups, respectively. The total compliance rates for the 47 subjects that concluded the study were 88, 77, 89, 85 and 81 for the 0, 1.7, 3.4, 5.1 and the 6.8 g CLA groups, respectively. No significant differences among groups regarding withdrawal or total compliance rates were observed.

Effects of CLA on weight and body composition. None of the groups had a significant reduction in weight or BMI after 12 wk of treatment (**Table 2**). No differences were observed among the different treatment groups for these variables. However, when BFM over the course of the study was analyzed (**Table 3**), differences among treatment groups were found. When active groups were tested pairwise against placebo, significant differences in favor of the 1.7, 3.4 and 6.8 g CLA groups were found. Within the different groups, a significant reduction in BFM was found in the 3.4 and 6.8 g CLA groups (Table 3) after 12 wk of treatment.

No difference was found among the five treatment groups in

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TABLE 1

Demographic data and baseline characteristics[1]

		Gender					
		F	M	Age	Height	Weight	BMI
	K	*n*		*y*	*cm*	*kg*	*kg/m²*
Placebo	10	8	2	44.4 ± 13.2	169 ± 9	79.8 ± 6.0	28.0 ± 2.4
CLA 1.7 g	12	8	4	47.2 ± 13.5	173 ± 10	88.6 ± 10.4	29.7 ± 2.5
CLA 3.4 g	8	5	3	42.8 ± 10.4	174 ± 7	83.6 ± 8.2	27.7 ± 2.1
CLA 5.1 g	11	7	4	47.7 ± 11.3	171 ± 11	86.2 ± 14.6	29.4 ± 2.6
CLA 6.8 g	11	7	4	44.3 ± 12.7	172 ± 8	90.1 ± 13.5	30.3 ± 2.9

[1] Demographic data and baseline characteristics were recorded at the first visit (wk 0). The values for age, height, weight and body mass index (BMI) are given as means ± SD. None of these characteristics were different among the groups at study start (ANOVA *F*-test).

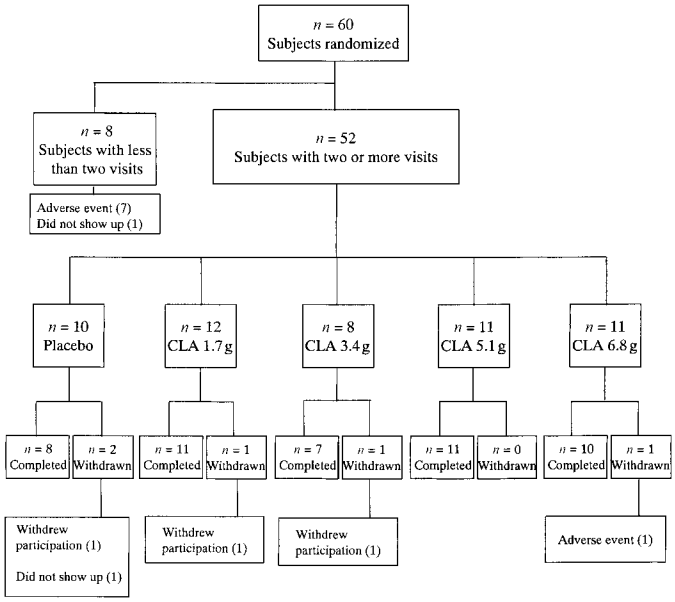

FIGURE 1 Disposition of subjects ($n = 60$) during the study. Eight subjects withdrew during the first 6 wk and 5 subjects withdrew between wk 6 and 12. Forty-seven subjects completed the study. Only subjects with two visits or more [at least wk 0 (baseline) and 6] were included in the main analysis.

LBM, although the increased LBM seen within all CLA groups was not seen in the placebo group (Table 3). However, only the 6.8 g CLA group showed a significant increase in LBM from wk 0 (baseline) to wk 12 (Table 3)(**Fig. 2**).

The 6.8 g CLA group was the only group with significant increases in the number of hours of intensive training during the study, whereas the 5.1 g CLA group showed a significant decrease in light training during the study (**Table 4**). No significant differences were found among the groups regarding either intensive or light training.

Clinical laboratory analyses and vital sign observations. Blood samples were analyzed to monitor safety and effects of the CLA treatment. Some changes were observed within each group. In the placebo group, a significant increase in glucose after 12 wk was found ($P = 0.02$). In all CLA-treated groups, significant reductions in blood lipids (total cholesterol, HDL cholesterol or LDL cholesterol) were found (**Table 5**). Additionally, a significant increase in potassium ($P = 0.02$), and a decrease in serum creatinine ($P = 0.004$) and platelets ($P = 0.02$) were found in the 3.4 g CLA group. In the 5.1 g CLA group, significant reductions in serum creatinine ($P = 0.05$) and bilirubin ($P = 0.05$) were found. A significant reduction in creatine-phosphokinase ($P = 0.03$) was found in the 6.8 g CLA group. None of these changes, however, were considered clinically important.

TABLE 2

Body weight and body mass index (BMI) of obese and overweight men and women given placebo or varying amounts of CLA[1,2]

		Week			
Treatment group	*n*	0	6	12	Δ, wk 0–12
Weight, *kg*					
Placebo	8	80.8 ± 6.4	81.3 ± 7.0	82.2 ± 7.3	1.4 ± 1.9
CLA 1.7 g	11	87.8 ± 10.4	87.7 ± 10.0	87.4 ± 9.0	−0.4 ± 2.6
CLA 3.4 g	7	82.6 ± 8.3	82.9 ± 8.6	82.2 ± 9.5	−0.4 ± 1.7
CLA 5.1 g	11	86.2 ± 14.6	86.8 ± 14.8	86.1 ± 15.0	−0.1 ± 0.9
CLA 6.8 g	10	89.4 ± 14.0	89.1 ± 14.6	88.6 ± 13.7	−0.8 ± 2.0
BMI, *kg/m²*					
Placebo	8	28.1 ± 2.4	28.3 ± 2.5	28.6 ± 2.6	0.5 ± 0.7
CLA 1.7 g	11	29.9 ± 2.5	29.9 ± 2.5	29.8 ± 2.3	−0.1 ± 0.9
CLA 3.4 g	7	27.2 ± 1.6	27.3 ± 1.5	27.1 ± 1.9	−0.2 ± 0.5
CLA 5.1 g	11	29.4 ± 2.6	29.6 ± 2.7	29.4 ± 2.7	−0.0 ± 0.3
CLA 6.8 g	10	30.4 ± 3.0	30.3 ± 3.0	30.2 ± 2.8	−0.3 ± 0.7

[1] Each value is the mean ± SD. None of the changes within the groups or the differences among the groups were significant.
[2] Measurements of weight and body mass index (BMI) were made at each visit (wk 0, 6 and 12).

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TABLE 3

Body fat mass (BFM) and lean body mass (LBM) of obese and overweight men and women given placebo or varying amounts of CLA[1]

Treatment group	*n*	Week 0	Week 6	Week 12	Δ, wk 0–12
BFM, *kg*					
Placebo	8	30.8 ± 6.0	31.0 ± 5.9	32.3 ± 7.4	1.47 ± 2.43
CLA 1.7 g	11	34.4 ± 6.9	34.3 ± 7.3	33.3 ± 6.1	−1.15 ± 2.69^{+}
CLA 3.4 g	7	30.1 ± 4.8	29.4 ± 5.0	28.3 ± 5.1	−1.73 ± 1.90^{+*}
CLA 5.1 g	11	33.6 ± 7.2	33.7 ± 7.2	33.2 ± 7.2	−0.43 ± 1.74
CLA 6.8 g	10	34.7 ± 9.7	34.4 ± 9.7	33.4 ± 8.9	−1.30 ± 1.46^{+*}
LBM, *kg*					
Placebo	8	45.7 ± 8.9	45.9 ± 9.0	45.6 ± 9.8	−0.05 ± 2.43
CLA 1.7 g	11	48.7 ± 10.3	48.8 ± 10.5	49.5 ± 9.7	0.87 ± 1.57
CLA 3.4 g	7	47.8 ± 9.3	48.3 ± 9.6	49.1 ± 9.8	1.26 ± 2.17
CLA 5.1 g	11	48.0 ± 12.4	48.5 ± 12.7	48.6 ± 12.9	0.54 ± 1.44
CLA 6.8 g	10	50.1 ± 11.1	50.1 ± 11.6	51.0 ± 10.6	0.88 ± 1.06*

[1] Each value is the mean ± SD. Significant changes within each group are marked with *($P \leq 0.05$) and difference between a CLA group and placebo is marked with $^{+}$($P \leq 0.05$). Taken together, the data show a significant reduction in BFM in the CLA-treated groups compared with the placebo group ($P = 0.03$).

No clinically important changes were found in heart rate or blood pressure over the course of the study. Among the dose groups, there were no differences in safety variables.

Adverse events. The frequency of adverse events in the original 60 subjects was 60% (36/60), and no significant differences among the different treatment groups were observed. In eight subjects, adverse events resulted in subject withdrawals, but the treatment groups did not differ significantly regarding rate of withdrawal related to adverse event. One of these adverse events was serious because the subject was hospitalized due to a relapse of asthma, but this adverse event was not judged to be drug related (the subject was in the 3.4 g CLA group). Of all adverse events reported, one was considered to be severe (fatigue); the remainder were of a mild-to-moderate character. The most frequent adverse events were gastrointestinal symptoms. These events could be drug related. The numbers of possibly drug related adverse events were 3, 5, 9, 8 and 11 in the placebo, 1.7, 3.4, 5.1 and 6.8 g CLA groups, respectively. Of these 36 adverse events, 20 were gastrointestinal symptoms. Altogether, 55% of the adverse events were considered to have a possible connection to the study treatment. No difference was found among the groups regarding the frequency of possible drug-related events.

As pointed out above, adverse events resulted in eight subject withdrawals; seven of these were in active treatment groups and one in the placebo treatment group. The other subjects had transient adverse events that disappeared during continuous treatment without any dose adjustments.

Quality of life. The VAS assessed possible treatment effects on some aspects of the quality of life. Positive changes, i.e., a subjective experience of improvement of the conditions monitored by the VAS were observed only in the CLA-treated groups (**Table 6**).

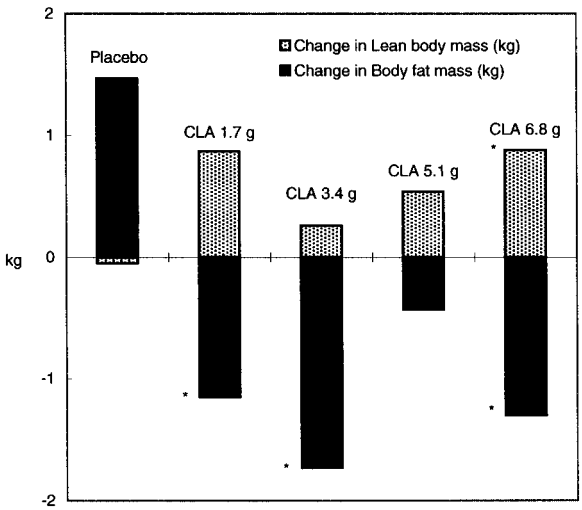

FIGURE 2 Body fat mass and lean body mass in obese and overweight men and women given placebo or varying amounts of CLA. Body fat mass and lean body mass were measured by dual-energy X-ray absorptiometry at wk 0 and 12 and expressed as the difference between the values at wk 0 and 12. *$P \leq 0.05$ for significance of difference between CLA treatment group and placebo group.

DISCUSSION

The present data indicate that consumption of CLA reduces BFM in overweight and moderately obese healthy volunteers. A significant reduction in BFM was found in the 3.4 and 6.8 g CLA groups. Moreover, when testing the active groups pairwise against placebo, the 1.7, 3.4 and 6.8 g CLA groups were different from the placebo group. These results are in contrast to those of Atkinson (1999), who did not find any differences between the CLA group (2.7 g CLA) and the placebo group in a 6-mo placebo-controlled, randomized, double-blind study in obese volunteers. However, some studies have been performed in subjects of normal weight that demonstrate an effect of CLA on body composition. In a placebo-controlled, double-blind trial by Vessby and Smedman (1999), the reduction of body fat after 12 wk of treatment with 4.2 g CLA/d was 1.2% ($P < 0.0001$). On the other hand, Kreider [reviewed in Doyle (1998)] did not find that CLA affected body fat in weight lifters with an initially low body fat percentage (14%). However, CLA had a positive effect on muscle strength and the ability to handle training and immune stress. This is interesting because the only group in this study that

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TABLE 4

Average training hours of obese and overweight men and women given placebo or varying amounts of CLA

Treatment group	*n*	Week 0	Week 6	Week 12	Δ, wk 0–12
Intensive training, *h*					
Placebo	8	1.0 ± 0.9	2.4 ± 2.3	0.9 ± 0.8	−0.1 ± 1.3
CLA 1.7 g	11	0.6 ± 1.3	0.7 ± 0.8	0.2 ± 0.4	−0.4 ± 1.1
CLA 3.4 g	7	0.3 ± 0.8	0.3 ± 0.8	1.3 ± 2.2	1.0 ± 1.5
CLA 5.1 g	11	0.3 ± 0.6	1.9 ± 2.5	1.6 ± 2.2	1.3 ± 2.4
CLA 6.8 g	10	0.5 ± 1.3	1.1 ± 1.7	1.7 ± 1.6	1.2 ± 1.3*
Light training, *h*					
Placebo	8	1.5 ± 1.4	3.9 ± 6.7	1.4 ± 1.2	−0.1 ± 1.1
CLA 1.7 g	11	3.1 ± 2.4	3.2 ± 4.3	3.3 ± 4.1	0.2 ± 3.9
CLA 3.4 g	7	2.3 ± 3.3	2.6 ± 2.4	2.1 ± 2.6	−0.2 ± 3.3
CLA 5.1 g	11	3.5 ± 2.6	3.2 ± 3.1	1.8 ± 2.4	−1.7 ± 2.2*
CLA 6.8 g	10	1.8 ± 1.5	2.6 ± 2.0	2.2 ± 2.6	0.4 ± 3.3

[1] A specialized training program was designed for the subjects at a local training center. The amount of training of each subject was recorded and grouped as hours of intensive or light training. Each value is the mean ± SD. No differences were observed among the treatment groups for either intensive or light training hours. * $P \leq 0.03$ for significance of change from wk 0 to 12 within the treatment group.

TABLE 5

Serum lipase activity and blood lipids of obese and overweight men and women given placebo or varying levels of CLA[1]

Registration	Placebo *n* = 8	CLA 1.7 g *n* = 11	CLA 3.4 g *n* = 7	CLA 5.1 g *n* = 11	CLA 6.8 g *n* = 10
			Δ, *wk 0–12*		
Triglycerides, *mmol/L*	0.07 ± 0.3	0.09 ± 0.4	0 ± 0.5	0.04 ± 0.6	0.04 ± 0.3
Total cholesterol, *mmol/L*	−0.3 ± 0.9	−0.4 ± 0.5*	−0.4 ± 0.3*	−0.2 ± 0.6	−0.2 ± 0.6
LDL cholesterol, *mmol/L*	−0.2 ± 0.8	−0.3 ± 0.4*	−0.3 ± 0.3*	−0.1 ± 0.7	−0.1 ± 0.5
HDL cholesterol, *mmol/L*	−0.1 ± 0.2	−0.1 ± 0.1+	−0.1 ± 0*	−0.1 ± 0.1*	−0.2 ± 0.2+
Serum lipase activity, *U/L*	0 ± 21	0 ± 13.3	−5 ± 22.6	−1 ± 10.8	−4 ± 20.4
Lipoprotein (a), *mg/L*	2 ± 74.9	−2 ± 45.9	13 ± 34.1	2 ± 49.1	22 ± 41.1

[1] Blood lipid analyses were performed at baseline and wk 12. The difference from wk 0 to 12 is the mean ± SD. * $P \leq 0.05$ for significance of change from wk 0 to 12 within the treatment group; + $P < 0.01$ for significance of change from wk 0 to 12 within the treatment group.

TABLE 6

Subject visual analog scales (VAS) registrations in obese and overweight men and women given placebo or varying levels of CLA[1]

Registration	Mean change from baseline: Placebo	CLA 1.7 g	CLA 3.4 g	CLA 5.1 g	CLA 6.8 g
			mm		
Sleep	4.5 ± 22.9 (8)	−7.6 ± 11.1 (11)*	−8.3 ± 21.0 (7)	−3.8 ± 8.8 (11)	−3.6 ± 3.6 (10)**
Gain from training	−3.8 ± 22.5 (8)	−6.5 ± 10.5 (11)	−10.9 ± 14.3 (7)*	−7.0 ± 15.9 (11)	−1.6 ± 14.3 (10)
Appetite	−2.1 ± 5.6 (8)	−1.7 ± 4.3 (11)	−6.7 ± 3.1 (7)†	−1.2 ± 3.7 (11)	−2.7 ± 3.6 (10)*
Mood	−3.5 ± 5.6 (8)	0.5 ± 11.9 (11)	−6.6 ± 2.4 (7)†	−1.7 ± 3.7 (11)	−2.5 ± 4.0 (10)
Stress	18.8 ± 31.9 (8)	−14.9 ± 25.0 (11)**	−4.6 ± 2.6 (7)**	−9.7 ± 20.9 (11)*	−9.2 ± 12.0 (10)
Working capacity	−6.8 ± 9.3 (6)	−3.1 ± 3.8 (10)*	−4.5 ± 1.9 (10)**	−1.8 ± 4.6 (10)	−4.7 ± 5.4 (10)*
Leisure activity	−13.0 ± 15.1 (6)	−3.1 ± 3.6 (10)*	−2.7 ± 7.7 (6)	−7.2 ± 7.2 (10)*	−8.9 ± 16.1 (10)

[1] The individual assessments of questions related to sleep, gain from training, appetite, humor, stress, working capacity and leisure activity during the last 14 d were recorded at wk 0 (baseline) and wk 12. The subjects were asked to score the different categories by putting a mark between the endpoints [0 mm (not at all satisfied) and 100 mm (completely satisfied)]. The difference from wk 0 to 12 is given as the mean ± SD with the number of subjects in parentheses. * $P \leq 0.05$ for significance of change from wk 0 to 12 within the treatment groups; ** $P < 0.01$ for significance of change from wk 0 to 12 within the treatment groups; † $P < 0.001$ for significance of change from wk 0 to 12 within the treatment groups.

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had a significant increase in LBM was the group that had intensified their training. Whether the increased LBM is an effect of the increased training activities or an effect of CLA intake is difficult to decide. However, a small, albeit not significant increase was seen in all CLA-treated groups.

The CLA preparation used in this study contained equal amounts of the *cis*-9, *trans*-11 isomer and the *trans*-10, *cis*-12 isomer. The effects of CLA presented in this study could therefore result from either or both of these isomers. The *cis*-9, *trans*-11 isomer has been regarded as the biologically most active isomer because of its abundance relative to the other isomers in biological membranes of mice and rats (Ha et al. 1990, Ip et al. 1991). However, the *trans*-10, *cis*-12 isomer has been associated with reduced BFM and enhanced body protein in mice, whereas no such changes in body composition have been found due to the *cis*-9, *trans*-11 isomer (Park et al. 1999b). Furthermore, the *trans*-10, *cis*-12 isomer, but not the *cis*-9, *trans*-11 isomer has been found to reduce lipoprotein lipase activity, intracellular triacylglycerol and glycerol, and to enhance glycerol release into the medium in cultured 3T3-L1 adipocytes (Park et al. 1999b). Interestingly, the ratio of *cis*-9, *trans*-12 and *trans*-10, *cis*-12 varies dependent on the tissue (Park et al. 1995). This means that individual CLA isomers may trigger different responses in different tissues. Thus, the effect of CLA on LBM may be uncoupled from the effect of CLA on BFM.

In this study, blood CLA levels were not measured. This may be of importance because the subjects may vary with respect to the quantity of CLA-rich food they ingest per day.

An effect of CLA on early arteriosclerosis, concomitant with a reduction in plasma total and LDL cholesterol levels, was reported in rabbits (Lee et al. 1994) and hamsters (Nicolosi et al. 1993). Clinically important reductions in total or LDL cholesterol were not seen in this study. It may be that the treatment period was too short for such reductions to appear, but divergent responses in different species and the initial level of cholesterol may also play a role.

A reduction in the HDL level was found in all the CLA-treated groups after 12 wk of treatment. This reduction might be of importance and should be investigated in future studies. In addition, the reduced LDL cholesterol level found in the 1.7 and 3.4 g CLA-treated groups after 12 wk might be of some importance.

Both withdrawal rates and the occurrence of adverse events were quite high in the study. This may be caused by the number of capsules that were to be taken each day (12 capsules). As reported by Vessby and Smedman (1999), the dominant nuisances reported were of gastrointestinal origin. These events could have been caused by the capsules or the oil per se rather than the high content of CLA.

In general, the subjects in the present trial participated with the goal of improving some aspect of their quality of life. These results may be of importance, and future CLA studies should include validated measurements to investigate further the effects of CLA on general well-being.

In conclusion, we want to emphasize that the beneficial effects of CLA with regard to BFM and LBM are promising. The number of subjects in this study was relatively small and may thus be a limiting factor in reaching general conclusions. However, at present, a dose of 3.4 g CLA/d for 12 wk seems to be sufficient to reduce BFM significantly in overweight and obese humans. A conclusion regarding the optimal dose of CLA and duration of treatment cannot be made on the basis of these limited data, but the current data provide a solid platform for future studies.

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