Incorporation of *cis*-9,*trans*-11 or *trans*-10,*cis*-12 conjugated linoleic acid into plasma and cellular lipids in healthy men

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Abstract This study investigated the incorporation of *cis*-9,*trans*-11 conjugated linoleic acid (c9,t11 CLA) and *trans*-10,*cis*-12-CLA (t10,c12 CLA) into plasma and peripheral blood mononuclear cell (PBMC) lipids when consumed as supplements highly enriched in these isomers. Healthy men (n = 49, age 31 ± 8 years) consumed one, two, and four capsules containing ~600 mg of either c9,t11 CLA or t10,c12 CLA per capsule for sequential 8 week periods followed by a 6 week washout before consuming the alternative isomer. Both isomers were incorporated in a dose-dependent manner into plasma phosphatidylcholine (PC) (c9,t11 CLA $r = 0.779$, t10,c12 CLA $r = 0.738$; $P < 0.0001$) and cholesteryl ester (CE) (c9,t11 CLA $r = 0.706$, t10,c12 CLA $r = 0.788$; $P < 0.0001$). Only t10,c12 CLA was enriched in plasma nonesterified fatty acids. Both c9,t11 CLA and t10,c12 CLA were incorporated linearly into PBMC total lipids ($r = 0.285$ and $r = 0.273$, respectively; $P < 0.0005$). The highest concentrations of c9,t11 CLA and t10,c12 CLA in PBMC lipids were 3- to 4-fold lower than those in plasma PC and CE. These data suggest that the level of intake is a major determinant of plasma and PBMC CLA content, although PBMCs appear to incorporate both CLA isomers less readily.—Burdge, G. C., B. Lupoli, J. J. Russell, S. Tricon, S. Kew, T. Banerjee, K. J. Shingfield, D. E. Beever, R. F. Grimble, C. M. Williams, P. Yaqoob, and P. C. Calder. **Incorporation of *cis*-9,*trans*-11 or *trans*-10,*cis*-12 conjugated linoleic acid into plasma and cellular lipids in healthy men. *J. Lipid Res.* 2004.** 45: **736–741.**

Supplementary key words phosphatidylcholine • cholesteryl ester • nonesterified fatty acids • leukocyte • human

Conjugated linoleic acid (CLA) is a collective term for 18 carbon fatty acids that differ in the geometry and position of two conjugated double bonds. CLA occurs naturally in meat and dairy products, which are the principal sources of these fatty acids in the human diet (1). *Cis*-9,*trans*-11 (c9,t11) is the major CLA isomer in dairy products, with lesser amounts of t7,c9 > c11,t13 > c8,t10 > t10,c12 (1).

A number of animal studies, primarily in rodents, show that increased consumption of CLA results in effects that may be potentially beneficial to human health (2), including antitumorigenic activity (3), decreased atherogenesis (4–6), decreased adiposity and increased lean body mass (7–9), and normalized glucose tolerance and nonesterified fatty acid (NEFA) concentration in Zucker rats (10). The effects of CLA on body composition have been attributed specifically to the activity of t10,c12 CLA (11, 12). Consumption of CLA in rodents also increased lymphocyte proliferation (13–16) and altered cytokine secretion (13–15).

In contrast to studies in animal models, there is marked variation among reports on the effects of increased CLA consumption on body composition (16–21) and immune function (22–24) in humans. All studies in humans reported to date have used mixtures of CLA isomers typically containing predominantly c9,t11 CLA and t10,c12 CLA in different ratios together with smaller amounts of other isomers. These range from relatively pure preparations containing c9,t11 CLA and t10,c12 CLA in ratios of 50:50 or 80:20 (22, 25–28) to complex mixtures (23, 29, 30). Thus, the dose of individual isomers may be relatively low despite high intakes of total CLA compared with the basal diet. Because some effects of CLA may be isomer-specific (11, 12, 31–40), differences in the intake of bio-

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Abbreviations: CE, cholesteryl ester; CLA, conjugated linoleic acid; FAME, fatty acid methyl ester; NEFA, nonesterified fatty acid; PBMC, peripheral blood mononuclear cell; PC, phosphatidylcholine.

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logically important isomers may explain, at least in part, the variations in outcome among studies in humans.

In the present study, we describe for the first time the effect of consuming increasing amounts of highly enriched preparations of c9,t11 CLA or t10,c12 CLA on their incorporation into plasma and cellular lipids in healthy men using a double-blind, crossover design. We report the concentrations of these isomers in plasma phosphatidylcholine (PC), cholesteryl ester (CE), and NEFA and in peripheral blood mononuclear cells (PBMCs).

MATERIALS AND METHODS

Materials

CLA supplements were provided by Natural ASA (Hovdebygda, Norway). Solvents were purchased from Fisher Ltd. (Loughborough, Leicestershire, UK), and all other reagents were from Sigma (Poole, Dorset, UK). Sodium methoxide was from Fluka (Sigma-Aldrich Co. Ltd., Gillingham, Dorset, UK). Fatty acid standards were from Sigma and Nu-Chek-Prep (Elysian, MN).

Subjects and study design

The study had a double-blind, crossover design. Forty-nine healthy men [age, 31 ± 8 years; body mass index (BMI), 24.6 ± 2.8 kg/m^2; fasting plasma triacylglycerol, 0.9 ± 0.2 mM; total cholesterol, 4.4 ± 0.8 mM] were recruited (24 in Southampton and 25 in Reading; the centers are ~60 miles apart). Identical protocols for sample collection and storage were used at both sites. The study was approved by the University of Reading Ethics and Research Committee and the South and West Hampshire Local Research Ethics Committee. Subjects gave written consent.

Subjects were randomly assigned, with stratification for age, BMI, and fasting triacylglycerol concentration, to consume initially either the c9,t11 CLA- or the t10,c12 CLA-enriched supplement as purified encapsulated triacylglycerol. Subjects maintained their habitual diets. The fatty acid compositions of the supplements and the daily intakes of c9,t11 CLA and t10,c12 CLA above the levels in the habitual diet are summarized in **Table 1**. Subjects consumed increasing amounts of the CLA supplements equivalent to one, two, and four capsules each for 8 weeks without a washout period between doses. After consumption of the highest dose, subjects ceased to consume the supplements for 6 weeks and then repeated this protocol with the alternative isomer.

Blood samples were collected at baseline and after each 8 week period. Sodium heparin was used as anticoagulant. Plasma was separated from cells by centrifugation and stored at −20°C in tubes containing butylated hydroxytoluene. PBMCs were isolated by centrifugation using Histopaque separation media (Sigma) as described elsewhere (41) and stored at −20°C.

Analysis of plasma and PBMC fatty acid composition

Plasma was extracted with chloroform-methanol (2:1, v/v) (42), and the total lipid fraction was separated into PC, CE, and NEFA by solid-phase extraction using aminopropyl silica cartridges (100 mg) (BondELut; Varian, Walton-on-Thames, Surrey, UK) as described elsewhere (43). Fatty acid methyl esters (FAMEs) were prepared from PC and CE using the methods of Christie (44) and Griinari et al. (45) as described elsewhere (46). The mixture was neutralized with oxalic acid [33.3% (w/v) in diethyl ether] and dried using calcium chloride to remove methanol residues. NEFAs were converted to FAMEs by incubation with methanol containing 2% (v/v) H_2SO_4 as described elsewhere (43). Total PBMC lipids, principally phospholipids, were extracted with chloroform-methanol (2:1, v/v) (42) and converted to FAMEs using methanol containing 2% (v/v) H_2SO_4 (43). There were no detectable selective losses or isomerization of either c9,t11 CLA or t10,c12 CLA using these techniques.

FAMEs derived from plasma CE and PC were resolved on a 100 m × 0.25 mm × 0.2 μm CPSIL-88 fused silica capillary column (Chrompack, Middelburg, The Netherlands) using a 3400 CX gas chromatograph (Varian Instruments, Walnut Creek, CA) equipped with flame ionization detection (FID) with hydrogen as the carrier gas as described elsewhere (46). Plasma NEFAs and PBMCs were resolved on a 100 m × 0.25 mm × 0.2 μm CPSIL-88 column using a 6890 gas chromatograph (Hewlett Packard, Wokingham, Berkshire, UK) with FID as described elsewhere (46) except that helium was used as the carrier gas. The differences in the analytical techniques used reflected the established methodologies at the two participating laboratories. Comparable resolution of individual fatty acids was obtained by both methodologies. Peaks were identified routinely by comparison of retention times with authentic FAME standards, which were confirmed in selected samples using their electron-impact ionization spectra with a reference library (data not shown). Fatty acid concentrations were calculated from baseline-corrected peak areas. The lower limit of detection of fatty acids in all lipid fractions was 0.01 g/100 g. Concentrations of c9,t11 CLA and t10,c12 CLA typically exceeded this limit by at least 10-fold in each of the samples collected after the supplement was consumed.

Statistical analysis

There were no period or period-treatment interactions between the arms of the crossover study for the same isomer supplement. CLA concentrations were normally distributed, and

TABLE 1. Fatty acid composition of capsules and daily intakes of supplemented fatty acids

	c9,t11 CLA-Enriched Capsules				t10,c12 CLA-Enriched Capsules			
Isomer	Fatty Acid Content	Intake at Each Dose of Supplement			Fatty Acid Content	Intake at Each Dose of Supplement		
	g/100 g	*mg/day*			*g/100 g*	*mg/day*		
Capsules per day		1	2	4		1	2	4
18:1n-9	5.8	44	88	176	1.7	13	26	52
c9,t11 CLA	79.3	595	1,190	2,380	10.6	80	160	320
t10,c12 CLA	7.8	59	118	236	84.1	631	1,262	2,524
Others	7.1	53	106	212	5.3	40	80	160

c9,t11 CLA, *cis*-9,*trans*-11 conjugated linoleic acid; t10,c12 CLA, *trans*-10,*cis*-12 CLA. Capsules contained 750 mg of triacylglycerol, of which 87.1% (654 mg) was CLA in the c9,t11 CLA-enriched capsules and 94.7% (711 mg) was CLA in the t10,c12 CLA-enriched capsules.

data were analyzed using parametric statistical tests. Comparisons between CLA concentrations at different doses of supplement were by one-way ANOVA with Bonferroni's post hoc test. Comparisons between CLA isomers at each dose and between baseline and after-maximum dose for the NEFA fraction were by paired Student's *t*-test. The relationship between CLA concentrations in different lipid pools was assessed by linear regression.

RESULTS

Concentrations of CLA isomers in plasma PC

c9,t11 CLA was readily detected in all plasma PC samples at baseline. However, mean fractional t10,c12 CLA concentration was consistently less than 0.01 g/100 g total fatty acids (Table 2). There were no significant differences in the concentrations of any of the fatty acids measured in the plasma PC fraction, including c9,t11 CLA and t10,c12 CLA, between baselines (**Table 2**). There were no significant differences in the concentrations of the 29 fatty acids measured in plasma PC either from baseline or between time points during the 24 weeks of the study (data not shown), apart from the CLA isomers contained in the supplements. Consumption of the c9,t11 CLA-enriched preparation was associated with a significant dose-dependent increase in the concentration of c9,t11 CLA in plasma PC ($r = 0.779$, $P < 0.0001$), with an overall 3.8-fold increase in fractional concentration between baseline and the end of the intervention (Table 2). Consumption of two and four capsules of the c9,t11 CLA-enriched preparation was also accompanied by a significant increase in t10,c12 CLA concentration (Table 2). Consumption of the t10,c12 CLA-enriched supplement resulted in a significant dose-dependent increase from a level below detection limits to 0.44% of total fatty acids ($r = 0.738$, $P < 0.0001$) (Table 2). This was accompanied by a 30% increase in c9,t11 CLA at the highest dose (Table 2). Comparison of the concentrations of c9,t11 CLA and t10,c12 CLA at each dose showed that the level of c9,t11 CLA in plasma PC was consistently greater (2.9-, 2.5-, and 1.8-fold; all $P < 0.0001$). Subtraction of the concentration of each isomer at baseline removed this difference such that there were no significant differences between isomers in incremental concentration when either the c9,t11 CLA-enriched supplement (one capsule, 0.13 ± 0.09 g/100 g total fatty acids; two capsules, 0.33 ± 0.151 g/100 g total fatty acids; four capsules, 0.61 ± 0.31 g/100 g total fatty acids) or t10,c12 CLA-enriched supplement (Table 2) was consumed.

Concentrations of CLA isomers in plasma CEs

There were no significant differences in the concentrations of any of the fatty acids measured in the CE fraction between baselines (Table 2) or between time points for the other 14 fatty acids routinely detected in the CE fraction (data not shown). The fractional concentration of c9,t11 CLA at baseline in the CE fraction was comparable to that of plasma PC (Table 2), whereas the t10,c12 CLA isomer was essentially undetectable (Table 2). When present as the major component of the supplement, both c9,t11 CLA and t10,c12 CLA increased in a dose-dependent manner in the CE fraction ($r = 0.706$, $P < 0.0001$ and $r = 0.788$, $P < 0.0001$, respectively) such that the overall increase was 3.8-fold and from 0 to 0.36 g/100 g total fatty acids, respectively (Table 2). c9,t11 CLA and t10,c12 CLA concentrations were increased significantly above baseline in the CE fraction when consumed as the minor isomer at the highest dose of the supplement (Table 2). As in the PC fraction, the apparent difference in the concentration of the major isomer consumed at each

TABLE 2. Concentrations of CLA isomers in plasma phosphatidylcholine, cholesteryl esters, and nonesterified fatty acids

	Fractional Concentration of CLA Isomers							
	c9,t11 CLA-Enriched Capsules per Day				t10,c12 CLA-Enriched Capsules per Day			
Isomer	0	1	2	4	0	1	2	4
Phosphatidylcholine								
N	47	46	41	38	48	48	46	44
c9,t11 CLA	0.21 ± 0.07	0.32 ± 0.09[a]	0.52 ± 0.19[b,c]	0.79 ± 0.28[b,c,e]	0.20 ± 0.09	0.21 ± 0.08	0.24 ± 0.08	0.26 ± 0.08[a,d]
t10,c12 CLA	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.02[b,d]	0.04 ± 0.02[b,c,e]	0.0 ± 0.0	0.11 ± 0.07[a]	0.21 ± 0.15[b,d]	0.44 ± 0.26[b,c,e]
Other CLA	0.01 ± 0.02	0.01 ± 0.02	0.01 ± 0.03	0.01 ± 0.01	0.0 ± 0.01	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
Cholesteryl esters								
N	47	46	41	38	48	48	46	44
c9,t11 CLA	0.20 ± 0.07	0.32 ± 0.08[a]	0.49 ± 0.17[a,c]	0.76 ± 0.28[b,c,e]	0.19 ± 0.07	0.2 ± 0.06	0.23 ± 0.07	0.25 ± 0.08[b,d]
t10,c12 CLA	0.00 ± 0.01	0.01 ± 0.02	0.01 ± 0.02	0.02 ± 0.02[b,c,e]	0.0 ± 0.01	0.09 ± 0.06[b]	0.18 ± 0.08[b,c]	0.36 ± 0.19[b,c,e]
Other CLA	0.0 ± 0.01	0.0 ± 0.01	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.01	0.0 ± 0.01	0.01 ± 0.02	0.01 ± 0.03
Nonesterified fatty acids								
N	34			34	35			33
c9,t11 CLA	0.36 ± 0.37	ND	ND	0.69 ± 0.35	0.34 ± 0.20	ND	ND	0.37 ± 0.33
t10,c12 CLA	0.03 ± 0.08	ND	ND	0.10 ± 0.15	0.03 ± 0.14	ND	ND	0.28 ± 0.29[f]

Results are mean concentrations (g/100 g fatty acids) ± SD. ND, not determined.
[a] Significantly different from baseline ($P < 0.05$).
[b] Significantly different from baseline ($P < 0.0001$).
[c] Significantly different from one capsule ($P < 0.0001$).
[d] Significantly different from one capsule ($P < 0.01$).
[e] Significantly different from two capsules ($P < 0.0001$) by one-way ANOVA with Bonferroni's post hoc correction for multiple comparisons.
[f] Significantly different from baseline ($P < 0.05$) by Student's paired *t*-test.

dose between c9,t11 CLA and t10,c12 CLA (3.6-, 2.7-, and 2.1-fold, $P < 0.0001$ at all doses) was accounted for by the difference in baseline concentrations. There were no significant differences in the incremental concentrations between c9,t11 CLA (one capsule, 0.09 ± 0.01 g/100 g total fatty acids; two capsules, 0.21 ± 0.17 g/100 g total fatty acids; four capsules, 0.40 ± 0.32 g/100 g total fatty acids) and t10,c12 CLA (Table 2). When present as the major isomer in the supplement, there were highly significant positive associations across the range of doses consumed between plasma PC and CE c9,t11 CLA ($r = 0.513$, $P < 0.0001$) or t10,c12 CLA ($r = 0.897$, $P < 0.0001$) concentrations.

Concentrations of CLA isomers in plasma NEFAs

The CLA content of plasma NEFA was only determined at baseline and after consumption of the highest dose of each CLA supplement. There were no significant differences in the concentrations of any fatty acid measured between baselines (Table 2) or between baseline and after consumption of the highest intake of supplement for the other 13 fatty acids detected in this fraction (data not shown). Baseline c9,t11 CLA and t10,c12 CLA concentrations tended to be greater in the NEFA fraction than in PC or CE (Table 2), although this was not significant. There was a trend toward an increase in the c9,t11 CLA content of plasma NEFA after consumption of the highest dose of the c9,t11 CLA-enriched supplement, but this was not significant. In contrast, the fractional concentration of t10,c12 CLA increased significantly (9.3-fold) when this isomer was consumed (Table 2). However, the increment in c9,t11 CLA concentration (0.33 ± 0.37 g/100 g total fatty acids) was not significantly different from that for the t10,c11 CLA isomer (Table 2). There was also a trend toward an increase in t10,c12 CLA concentration, but not c9,t11 CLA content, when consumed as the minor isomer (Table 2).

Concentrations of CLA isomer PBMC total lipids

There were no significant differences between baselines in the concentration of fatty acids in PBMC total lipids (**Table 3**). The concentrations of the other 26 fatty acids detected in PBMC lipids did not change with increasing consumption of the supplements (data not shown). c9,t11 CLA and t10,c12 CLA were readily detected in PBMC total lipids at baseline (Table 3). The fractional concentration of c9,t11 CLA in PBMC total lipids (Table 3) was significantly lower ($P < 0.0001$) than that in the plasma PC or CE fractions (Table 2), although there was no such difference for the t10,c12 isomer. Consumption of c9,t11 CLA- or t10,c12 CLA-enriched capsules was associated with a significant dose-dependent increase ($r = 0.285$, $P < 0.0005$ and $r = 0.273$, $P < 0.0005$, respectively) in the fractional concentrations of these isomers in total PBMC lipids, so that the overall increase was 2.8-fold for c9,t11 CLA and 3.7-fold for t10,c12 CLA (Table 3). However, the magnitude of the overall increase in PBMC c9,t11 CLA content was significantly less than that for plasma PC (3.6-fold, $P < 0.0001$) or CE (3.5-fold, $P < 0.0001$) fractions (Table 2). There was no significant increase in t10,c12 CLA concentration when present as the minor CLA component of the supplement, whereas c9,t11 CLA concentration was significantly increased above baseline after the highest dose (Table 3). Consumption of the t10,c12 CLA-enriched supplement resulted in an increase in the fractional concentration of t10,c12 CLA in PBMC total lipids (Table 3). However, this was not significantly associated with the dose consumed (Table 3). The concentration of t10,c12 CLA after consumption of the highest dose of the t10,c12 CLA-enriched preparation was significantly less (50%, $P = 0.002$) than for c9,t11 CLA after consumption of the c9,t11 CLA-enriched supplement (Table 3), although this difference was attributable to the higher background concentration of c9,t11 CLA. The t10,c12 CLA concentration in PBMC after consumption of the highest dose was significantly lower than in plasma PC (4-fold, $P < 0.0001$) and CE (3-fold, $P < 0.0001$) (Table 2).

There was a positive association between c9,t11 CLA concentration in PBMC and plasma PC and CE ($r = 0.417$, $P < 0.0001$ and $r = 0.228$, $P < 0.01$, respectively). However, there was no significant association between plasma PC and CE t10,c12 CLA concentrations and the concentration of this isomer in PBMC total lipids ($r = 0.118$ and $r = 0.140$, respectively).

DISCUSSION

The results of this study show that c9,t11 CLA and t10,c12 CLA isomers are readily incorporated into plasma

TABLE 3. Concentrations of CLA isomers in peripheral blood mononuclear cell total lipids

	Fractional Concentration of CLA Isomers							
	c9,t11 CLA-Enriched Capsules per Day				t10,c12 CLA-Enriched Capsules per Day			
Isomer	0	1	2	4	0	1	2	4
N	45	43	37	35	47	42	40	38
c9,t11 CLA	0.08 ± 0.07	0.12 ± 0.08	0.17 ± 0.10	0.22 ± 0.13[a]	0.10 ± 0.13	0.08 ± 0.07	0.14 ± 0.09	0.19 ± 0.1[b,c]
t10,c12 CLA	0.03 ± 0.06	0.04 ± 0.06	0.05 ± 0.06	0.06 ± 0.06	0.03 ± 0.09	0.09 ± 0.06[a]	0.13 ± 0.12[b]	0.11 ± 0.11[a]

Results are mean concentrations (g/100 g fatty acids) ± SD.
[a] Significantly different from baseline ($P < 0.05$).
[b] Significantly different from baseline ($P < 0.0001$).
[c] Significantly different from one capsule ($P < 0.0001$).

lipids and PBMCs in a dose-dependent manner when they are consumed in the diet.

c9,t11 CLA was detected at baseline in all lipid fractions measured. Because c9,t11 CLA is the major CLA isomer in the diet (1), the concentration of this isomer at baseline probably reflects habitual intakes. The t10,c12 CLA isomer is at most a minor dietary component and was essentially absent from plasma PC and CE at baseline. The fractional concentrations of both CLA isomers at baseline in PC and CE were comparable to those reported previously for total plasma lipids (22, 26, 28, 30) and for plasma PC (22), but c9,t11 CLA concentration at baseline in the CE fraction was ~3-fold greater than that reported previously (22).

Both c9,t11 CLA and t10,c12 CLA were incorporated into plasma PC and CE in a dose-dependent manner, an effect that has not been demonstrated previously in single isomer preparations. This suggests that dietary intake is a major determinant of the CLA content of these lipid pools. This is supported by one study using a mixture of isomers (28), although others did not find this (27). There was no evidence of differential incorporation of these isomers into plasma PC and CE. This is in contrast to the findings of Petridou, Mougios, and Sagredos (22), who failed to show an increase in plasma CE c9,t11 CLA or t10,c12 CLA concentrations, possibly because of the low intakes of these isomers (350 mg/day of each isomer). However, we detected significant increases in c9,t11 CLA and t10,c12 CLA in both plasma PC and CE when present as the minor CLA isomer in the supplements, providing intakes comparable to those reported by Petridou, Mougios, and Sagredos (22). The positive association in the concentration of c9,t11 CLA or t10,c12 CLA between plasma PC and CE may reflect the synthesis of plasma CE from PC by lecithin:cholesterol acyltransferase activity.

In fasting subjects, plasma NEFAs are derived primarily from the mobilization of adipose triacylglycerol stores (47) and therefore represent a proxy marker of the incorporation of dietary fatty acids into adipose tissue. The fatty acid composition of the NEFA pool was more variable than that of the PC and CE fractions, possibly because of differences in dietary history among subjects. Baseline c9,t11 CLA concentration was similar to that reported previously for total NEFA CLA content (22). There was a nonsignificant trend toward increased c9,t11 CLA concentration, whereas greater consumption of t10,c12 CLA increased the concentration of this isomer significantly in plasma NEFA. This suggests a small increase in the CLA content of adipose tissue, in general agreement with previous observations (27, 30).

Both c9,t11 CLA and t10,c12 CLA were detected in PBMC total lipids. The concentrations of c9,t11 CLA and t10,c12 CLA increased in a dose-dependent manner, although the final concentration of each isomer was significantly less than that in the PC and CE fractions at each dose. This suggests that PBMCs are more resistant to the incorporation of these isomers than are plasma lipid pools. There was no evidence for the differential incorporation of these isomers into PBMCs. The highest concentrations of both c9,t11 CLA and t10,c12 CLA were comparable to those reported by Kelley et al. (23) in subjects consuming ~0.45 g of c9,t11 CLA and ~0.57 g of t10,c12 CLA per day but were ~6-fold lower than the total CLA content of PBMCs when volunteers consumed ~1.6 g of total CLA per day (25). The reason for this difference is not clear. There was a direct association between the amount of c9,t11 CLA in plasma PC and in PBMCs, which suggests that plasma PC and CE are important sources of c9,t11 CLA for uptake into PBMCs, although this was not found for t10,c12 CLA.

Overall, these two CLA isomers were incorporated to some extent into each of the lipid fractions studied. However, the relatively low incorporations into both plasma and PBMC lipids in this and other studies may explain, at least in part, the disappointing and variable effects of supplementation with CLA on biological outcomes in humans (48).

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