A Diet Rich in Coconut Oil Reduces Diurnal Postprandial Variations in Circulating Tissue Plasminogen Activator Antigen and Fasting Lipoprotein (a) Compared with a Diet Rich in Unsaturated Fat in Women[1]

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ABSTRACT The effects of high and low fat diets with identical polyunsaturated/saturated fatty acid (P/S) ratios on plasma postprandial levels of some hemostatic variables and on fasting lipoprotein (a) [Lp(a)] are not known. This controlled crossover study compared the effects of a high fat diet [38.4% of energy (E%) from fat; HSAFA-diet, P/S ratio 0.14], a low fat diet (19.7 E% from fat; LSAFA-diet, P/S ratio 0.17), both based on coconut oil, and a diet with a high content of monounsaturated fatty acids (MUFA) and PUFA (38.2 E% from fat; HUFA-diet, P/S ratio 1.9) on diurnal postprandial levels of some hemostatic variables ($n = 11$) and fasting levels of Lp(a) ($n = 25$). The postprandial plasma concentration of tissue plasminogen activator antigen (t-PA antigen) was decreased when the women consumed the HSAFA-diet compared with the HUFA-diet ($P = 0.02$). Plasma t-PA antigen was correlated with plasminogen activator inhibitor type 1 (PAI-1) activity when the participants consumed all three diets (Rs = 0.78, $P < 0.01$; Rs = 0.76, $P < 0.01$; Rs = 0.66, $P = 0.03$; on the HSAFA-, the LSAFA- and the HUFA-diet, respectively), although the diets did not affect the PAI-1 levels. There were no significant differences in postprandial variations in t-PA activity, factor VII coagulant activity or fibrinogen levels due to the diets. Serum fasting Lp(a) levels were lower when women consumed the HSAFA-diet (13%, $P < 0.001$) and tended to be lower when they consumed the LSAFA-diet (5.3%, $P = 0.052$) than when they consumed the HUFA-diet. Serum Lp(a) concentrations did not differ when the women consumed the HSAFA- and LSAFA-diets. In conclusion, our results indicate that a coconut oil–based diet (HSAFA-diet) lowers postprandial t-PA antigen concentration, and this may favorably affect the fibrinolytic system and the Lp(a) concentration compared with the HUFA-diet. The proportions of dietary saturated fatty acids more than the percentage of saturated fat energy seem to have a beneficial influence on Lp(a) levels. J. Nutr. 133: 3422–3427, 2003.

KEY WORDS: • *diet* • *fibrinolysis* • *coagulation* • *lipoprotein (a)* • *coconut oil* • *unsaturated fatty acids*

Both epidemiologic (1) and experimental data (2–4) have shown that hemostatic variables might be modified by diet. Hemostatic variables such as factor VII coagulant activity (FVIIc)[3] (2,4–7), fibrinogen (8,9), tissue plasminogen activator (t-PA) activity, (8,10,11), t-PA antigen (12), plasminogen activator inhibitor type 1 (PAI-1) activity (8,9,13) and PAI-1 antigen (9) have all been shown to be influenced by dietary factors. FVIIc has also been shown to be significantly related to the fat content of the diet (2,4–7,10). A study with young men who switched from a diet high in saturated fat to a low fat/high fiber diet did not show any difference in circadian variation in t-PA antigen or PAI-1 antigen concentrations (10).

Lipoprotein (a) [Lp(a)] was shown to be relatively unaffected by dietary changes, although in some studies saturated fatty acids decreased Lp(a) levels (14–16). Saturated fatty acids from a palm oil diet decreased Lp(a) significantly in healthy normocholesterolemic men compared with the habitual fat in a Dutch populaton (14), whereas a diet high in stearic acid was shown to increase Lp(a) compared with a diet with palmitic and myristic + lauric acids (17). Further, *trans* fatty acids from partially hydrogenated vegetable oil (16,18) and from partially hydrogenated fish oil (18) were found to increase Lp(a) levels in humans. Due to its structural similarity to plasminogen, Lp(a) has been suggested to competitively inhibit plasminogen through its binding sites on t-PA, streptokinase, endothelial cells, platelets and fibrin (19). However, no studies in vivo have found strong evidence for such a

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[3] Abbreviations used: CVD, cardiovascular disease; E%, percentage of energy; HSAFA-diet, diet high in saturated fatty acids (coconut oil); HUFA-diet, diet high in MUFA and PUFA; HUFA margarine, margarine high in MUFA and PUFA; Lp(a), lipoprotein (a); LSAFA-diet, diet low in saturated fatty acids (coconut oil); MUFA, monounsaturated fatty acids; P/S, polyunsaturated/saturated fatty acid ratio; PAI-1, plasminogen activator inhibitor type 1; t-PA, tissue plasminogen activator.

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mechanism (20). Moreover, in one study, Lp(a) was found to stimulate endothelial PAI-1 synthesis (21).

Several studies have been performed comparing the effects of high and low fat diets on serum lipoproteins (22). To our knowledge, no controlled study has been published in which the effect of high saturated fat on Lp(a) was compared directly with low saturated fat without change in the polyunsaturated/saturated fatty acid ratio (P/S ratio). The purpose of the present study was to compare the effects on plasma postprandial levels of some hemostatic variables and on fasting Lp(a) of high and low fat coconut oil–based diets with identical P/S ratios. A high fat diet with a high content of monounsaturated fatty acids (MUFA) and PUFA but otherwise identical to the high fat coconut oil diet was included for comparison.

SUBJECTS AND METHODS

Baseline characteristics and study design. Female students in home economics from University College of Akershus were invited to participate in this strictly controlled dietary study. Exclusion criteria were BMI > 32 kg/m^2 and pregnancy. Further details were previously described (22).

A total of 31volunteers fulfilled the criteria and entered the study and a subset of 13 students entered the diurnal postprandial study. Of these, 25 completed the original study, and 11 the subset study. Seven participants in the original study, and three in the subset used oral contraceptives and one used a hormone-releasing intrauterine device.

Mean age, weight and BMI of the participants in the original study were (mean ± SD) 30.5 ± 9.8 y, 67.4 ± 12.1 kg and 24.5 ± 3.2kg/m^2, respectively, and in the subgroup 34 ± 11.9 y, 74.6 ± 12 kg and 26.2 ± 3.2 kg/m^2, respectively.

The protocol and the objective of the study were explained in detail to the participants and they gave informed consent before entry into the study. No payment was given except for free food during the study. The study protocol was approved by the Regional Committee for Ethics in Biomedical Research of Norway.

The study took place from September to December, 1998, during 3 periods of 22 d for the first and second period, and 20 d for the third period with a wash-out period of 1 wk, which was judged to be sufficient based on previous literature (6,7). In the wash-out period, the participants returned to their habitual diet. Each person received the three diets by assignment to one of three sequences as directed by a Latin-square design (ABC, BCA, CAB). On the last day in the three periods, all meals were eaten under supervision at the University College. The breakfast, lunch, dinner and evening meals were served at 0800, 1100, 1430 and 1900 h, respectively. Body weight was monitored twice a week. BMI was calculated as weight (kg)/height (m)^2. Further details were described previously (22).

Test margarines and experimental test diets. Two different test margarines were used in the study. A saturated fatty acid–rich margarine that contained 80 g/100 g coconut oil, 10 g/100 g soybean oil and 10 g/100 g rapeseed oil was used in two different diets. One of these was intended to contain 22 E% fat (low saturated fatty acid diet, LSAFA-diet) and the other 42 E% fat (high saturated fatty acid diet, HSAFA-diet). A commercial soft highly unsaturated margarine consisting of coconut oil, palm oil, refined sunflower oil and refined rapeseed oil was used in the third diet, which was intended to contain 42 E% as fat (high MUFA and PUFA diet, HUFA-diet). Because of its content of sunflower oil, the HUFA-margarine contained more vitamin E than the other two diets. Total tocopherol was 35.5 mg/100 g in the HUFA-margarine and 16.4 mg/100 g in the SAFA-margarine.

The diets were based on a 7-d menu. They were calculated by using a computer-based, nutrient-calculation program and were designed to have almost the same nutrient composition except for the fatty acid composition, fat and carbohydrate content. The fat from the background diet was calculated to supply a minimal amount of 7.8 E% fat, whereas the test fat was planned to provide 34.2 E% in the high fat diet and 14.2 E% in the low fat diet. The HSAFA- and HUFA-diets were identical except for the test fat. In the LSAFA-diet, 18.7 E% of fat was exchanged for carbohydrates from fruits, orange juice and sugar candies and 1.6 E% from protein. Dinner was served under supervision in a dining room every day except on the weekend. The evening meal and breakfast for the next day were prepared and taken home by the participants. During the controlled feeding periods, no foods other than those in the menu were allowed. The subjects were supplied with food to meet 100% of their mean daily energy requirements. If the participants temporarily increased activity or lost weight, they were allowed to eat buns with the same fat composition as the rest of the diet. All foodstuffs were weighed for each individual subject. The HSAFA- and HUFA-diets were calculated to contain 109 g fat/10 MJ of which the test margarines provided 89 g; the LSAFA-diet was calculated to contain 57 g fat/10 MJ of which test margarine provided 37 g. The fatty acid composition and dietary cholesterol are discussed below. A normal level of dietary cholesterol is ~350–450 mg/d. The SAFA-margarine contained 16.3% water and the HUFA-margarine 16.1% water. Compliance with the diets was judged by direct observation of consumption of weekday dinners, by close personal follow-up and by evaluation of food diaries.

Chemical analysis of the diets. Duplicate portions of the three diets, corresponding to a daily energy intake of 8.2 MJ, were homogenized and freeze-dried. The homogenates, corresponding to 7 consecutive days from each diet, were pooled into one portion and kept frozen at −20° until analysis.

The protein and fat contents were determined after chloroform-methanol extraction (22). The metabolizable energy content of the diets was determined as described by Andersson et al. (23). The fatty acids of the respective fat extracts were converted to FAME and analyzed by GC as described by Almendingen et al. (18).

Blood sampling and analyses. The baseline blood samples were taken after an overnight fast, before breakfast. Fasting samples were collected at 0730 h on the last day in each period, followed by four nonfasting samples at 0930, 1230, 1600 and 2030 h drawn 1.5 h after each meal. On the next day another fasting blood sample was taken at 0730 h. All venipunctures were performed in the supine position after at least 15 min rest.

Citrated plasma (Vacutainer tubes, containing 0.129 mmol/L trisodium citrate in dilution 1:10) was separated within 15 min by centrifugation at 2500 × *g* for 30 min at 4°C for determination of PAI-1 activity, PAI-1 antigen, t-PA antigen and fibrinogen. Acidified plasma for t-PA activity measurements was obtained using Stabilyte tubes as described by Rånby et al. (24). PAI-1 activity and t-PA activity were measured amidolytically [Spectrolyse/PL (plasminogen) and Chromolize tPA, Biopool AB, Umå, Sweden]. ELISA methods with a double antibody technique were used for determinations of PAI-1 antigen (measuring free PAI-1 as well as in complex with t-PA) and t-PA antigen (measuring free t-PA as well in complex with PAI-1) (TintElize PAI-1 and TintElize, tPA Biopool AB, respectively). Fibrinogen was measured according to Clauss (25) using an ACL-3000 Coagulation System Analyzer (Instrumentation Laboratory, Milan, Italy).

Citrated plasma for determination of coagulation FVII was handled at room temperature to avoid cold activation before being frozen at −80°C. FVII coagulant activity (FVIIc) was determined in a two-stage chromogenic assay containing human placenta thromboplastin (CoA-Set FVII, Chromogenics AB, Mølndal, Sweden). Serum was prepared for Lp(a) quantitation [TintElize Lp(a), Biopool AB] according to the manufacturer's instructions.

The interassay CV were 8.0% for t-PA activity and 3.5% for t-PA antigen, 4.8% for PAI-1 activity, 9.8% for PAI-1 antigen, 3.6% for fibrinogen, 3.1% for FVIIc activity; for Lp(a) at 100 mg/L, it was 7.7% and at 400 mg/L, 2.7%.

Statistical methods. The postprandial and fasting results were analyzed by repeated-measures ANOVA for a crossover trial (General Linear Model). Comparisons between the sets of observations were based on within-subject differences. For the hemostatic variables, an effect of time and possible interaction effects between treatment and time were examined. When the analysis indicated a significant effect of diet ($P < 0.05$), the Bonferroni method was used for a pairwise comparison between the three diet groups. The Bonferroni method encompasses a downward adjustment of significance limits for the differences between the diets. A 5% significance level was applied in

all analyses. All *P*-values are two-tailed. The number of participants was limited and logarithmic transformation of skewed variables was performed before statistical computations and significance testing. Spearman correlation coefficients for hemostatic variables are presented when appropriate. The statistical package SPSS 8.0 (SPSS, Chicago, IL) was used for the data analysis.

RESULTS

Six participants dropped out of the main study; therefore 25 completed all of the diet periods (22). One person dropped out of the subset postprandial study and another did not deliver the evening sample in one of the test periods. Thus, data from 11 participants were evaluated. These two persons, however, completed the main study. Dietary compliance was recorded as very good and no significant deviations from the diets were noticed. Body weights of fasting subjects at the end of the first, second and third periods did not differ.

The energy content of the diets was identical, but slightly higher than planned (**Table 1**). The fat content was somewhat lower than planned. The two high fat diets (HSAFA- and HUFA-diets) had identical proportions of fat (38.4 and 38.2 E%, respectively), whereas the low fat diet (LSAFA-diet) had about half the fat replaced by carbohydrates and contained 19.7E% as fat. The HSAFA-diet contained 100.9 g fat/10 MJ, the LSAFA-diet 51.7 g fat/10 MJ, and the HUFA-diet 100.5 g fat/10 MJ. The protein content was 15% in the HSAFA-diet and the HUFA-diet and was slightly higher i.e., 16.5% in the LSAFA-diet. All three diets were low in cholesterol (Table 1).

The HSAFA- and the LSAFA-diets had the same relative fatty acid composition with almost the same P/S ratio, 0.14 and 0.17, respectively (**Table 2**). However, the energy content of the cholesterol-increasing fatty acids 12:0, 14:0, 16:0 was about twice as high in the HSAFA- as in the LSAFA-diet. The main difference in fatty acid composition between the HSAFA-and the HUFA-diet was the higher amount of oleic acid (18:1) and linoleic acid (18:2) in the HUFA-diet and the higher amount of saturated fatty acids in the HSAFA-diet (Table 2).

Concentrations of blood hemostatic variables in the subset of women at baseline and after consumption of the three diets are shown in **Table 3**. There was less change in the diurnal plasma t-PA antigen concentration when the women consumed the HSAFA-diet than the HUFA-diet ($P = 0.02$) (**Table 4**, **Fig. 1**). The standard error of the difference between the means was very low (0.009). Diurnal postprandial changes in t-PA antigen concentration did not differ when the women consumed the other diets. Diurnal postprandial t-PA, fibrinogen concentration and FVIIc were not affected by the diets (Table 4). Time affected the hemostatic variables, but the treatment × time interactions were not significant.

Plasma t-PA antigen was correlated with plasma PAI-1 activity in women consuming all of the diets ($R = 0.78$, $P < 0.01$, $R = 0.76$, $P < 0.01$, $R = 0.66$, $P = 0.03$ for the HSAFA-, the LSAFA- and the HUFA-diets, respectively).

The fasting serum Lp(a) concentration was lower in women consuming the HSAFA-diet compared with the HUFA-diet ($P < 0.0001$). The Lp(a) concentration tended to be lower ($P = 0.052$) in women consuming the LSAFA-diet compared with the HUFA-diet (**Table 5**). Fasting FVIIc concentrations did not differ among women consuming the three diets (Table 5).

TABLE 1

Energy and nutrient composition of duplicate portions of the test diets[1]

	HSAFA-diet[2]	LSAFA-diet[3]	HUFA-diet[4]
Energy, *MJ*	8.72	8.66	8.85
Protein, *% of energy*	14.9	16.5	15.0
Fat, *% of energy*	38.4	19.7	38.2
Carbohydrate, *% of energy*	46.7	63.8	46.8
Cholesterol, *mg/d*	51.1	49.3	56.9

[1] For fatty acid composition, see Table 2.
[2] Diet high in saturated fatty acids.
[3] Diet low in saturated fatty acids.
[4] Diet high in poly- and monounsaturated fatty acids.

TABLE 2

Fatty acid composition of the test diets[1]

Fatty acid	HSAFA-diet[2]	LSAFA-diet[3]	HUFA-diet[4]
	mol/100 mol total fatty acid		
6:0	0.6	0.7	—
8:0	6.4	5.2	0.2
10:0	4.7	3.9	0.2
12:0	34.3	27.4	2.0
14:0	13.9	12.6	0.7
16:0	10.8	13.4	9.4
16:1*c*	0.25	0.7	0.1
18:0	3.6	4.9	8.0
18:1*t*	0.5	0.7	—
18:1*c*	14	17	36.7
18:2*t*	0.3	—	—
18:2*c*	8.6	10.2	36.2
18:3*c*	1.6	1.7	4.6
20:0	0.1	0.1	0.4
20:1*t*	0.2	0.2	0.6
20:1*c*	0.1	—	—
22:0	<0.1	<0.1	0.2
12:0, 14:0, 16:0, *energy %*	22.7	10.5	2.4
cis MUFA, *energy %*	5.5	3.5	14.1
cis PUFA, *energy %*	3.9	2.3	15.6

[1] Data are from Ref. 22.
[2] Diet with a high content of saturated fatty acid-rich (SAFA) margarine that contained 80% coconut oil, 10% soybean oil and 10% rapeseed oil.
[3] Diet with a low content of SAFA margarine.
[4] Diet with a high content of monounsaturated fatty acids (MUFA) and PUFA.

DISCUSSION

The results of this study indicate that saturated fatty acids from the HSAFA-diet had a greater lowering effect on diurnal postprandial t-PA antigen than the HUFA-diet, although the difference in t-PA antigen between the two diets was small (Table 4, Fig. 1). Interestingly, it was reported in an epidemiologic study on insulin resistance syndromes that consumption of milk products with a high content of saturated fatty acids was inversely correlated with the levels of t-PA antigen, thus agreeing with our results in healthy individuals (12). In a paired comparison of a fatty fish diet and a diet with lean meat substituted for fish, the fish diet [(n-3) polyunsaturated fat] was associated with higher levels of t-PA antigen. Further, the fish diet was associated with higher, less beneficial levels of PAI-1 antigen and PAI activity (26). It is not easy to explain why high saturated fat in the present study had a lowering effect on tPA antigen. Coconut oil has special properties and effects and one cannot exclude that this may influence the results. To our

TABLE 3

Blood hemostatic variable concentrations in a subset of women at baseline and after consumption of a high fat diet rich in saturated fatty acids (HSAFA), a low fat diet rich in saturated fatty acids (LSAFA) and a high fat diet rich in unsaturated fatty acids (HUFA) each for 3 wk[1]

	Baseline	HSAFA-diet	LSAFA-diet	HUFA-diet
Fibrinogen, *g/L*	2.40 ± 0.44	2.44 ± 0.44	2.35 ± 0.33	2.53 ± 0.51
Factor VIIc, %	107.7 ± 28	114.2 ± 23	110.5 ± 23	112.7 ± 24
PAI-antigen, *μg/L*	21.4 ± 11.8	16.20 ± 10.5	18.3 ± 10.4	18.2 ± 11.0
PAI activity, *kU/L*	20.8 ± 7.9	13.5 ± 0.96	15.03 ± 7.76	16.97 ± 8.51
tPA antigen, *μg/L*	5.78 ± 2.2	5.03 ± 2.06	5.53 ± 2.16	5.74 ± 1.93
tPA-activity, *kIU/L*	0.57 ± 0.39	0.77 ± 0.26	0.68 ± 0.32	0.65 ± 0.36

[1] Values are means ± SD, $n = 11$.

knowledge, no other controlled dietary study has been published in which a diet rich in saturated fat (coconut oil) decreased diurnal postprandial t-PA antigen.

Because the t-PA antigen method used determines both free t-PA and t-PA in complex with PAI-1, it reflects mainly the levels of PAI-1 (27). Circulating t-PA molecules are quickly complexed and inhibited by PAI-1 (28,29). Further, Almendingen et al. (30) observed that PAI-1 activity was significantly reduced when a butter diet compared with a partially hydrogenated soybean oil diet was consumed. Although only t-PA antigen differed significantly among subjects consuming the three diets (Fig 1), the same postprandial diurnal profile was seen for PAI-1 activity and PAI-antigen (results not shown). Moreover, in the present study, t-PA antigen was significantly correlated with PAI-1 activity in women consuming all three diets. The postprandial levels of t-PA antigen, PAI-1 activity and PAI-1 antigen were highest in the morning, whereas t-PA activity was lowest in the morning (results not shown), in agreement with previous reports (11,31–34).

In a previous study, we observed that saturated fat had a postprandial circadian favorable (increasing) effect on the fibrinolytic activity assessed as t-PA activity compared with a diet with a high content of MUFA and PUFA (11). Of the three diets in that study, saturated fatty acids from palm oil had the most favorable effect on t-PA activity. However, our previous findings with nine participants were significant only before correcting for multiple comparisons (11). The power to detect significant differences was <0.80 in the present study. Hemostatic variables have rather large variation and it is therefore difficult to attain a satisfactory statistical power ≥ 0.80 in such studies. In the present subset study, the postprandial differences obtained were based on six diurnal measurements in each participant with 198 ($11 \times 6 \times 3$) measurements for each parameter in a Latin square model, thus decreasing the likelihood that the results are due to chance.

The BMI was somewhat different among the participants in the original study (24.5 kg/m^2) and in the subset study (26.2 kg/m^2). The 11 participants who completed the postprandial

TABLE 4

Diurnal postprandial variation of hemostatic variables in a subset of women ($n = 11$) between the dietary test periods after consumption of a high fat diet rich in saturated fatty acids (HSAFA), a low fat diet rich in saturated fatty acids (LSAFA) and a high fat diet rich in unsaturated fatty acids (HUFA) each for 3 wk[1]

	Mean difference	*P*-value	CI (95%)
Fibrinogen, *g/L*			
HSAFA-LSAFA	−0.019	0.113	(−0.04, 0.01)
LSAFA-HUFA	−0.035	0.785	(−0.03, 0.02)
HSAFA-HUFA	−0.023	0.083	(−0.05, 0.00)
Factor VIIc, %			
HSAFA-LSAFA	0.020	0.414	(−0.03, 0.07)
LSAFA-HUFA	−0.005	0.704	(−0.03, 0.02)
HSAFA-HUFA	0.014	0.449	(−0.03, 0.05)
PAI-antigen, *μg/L*			
HSAFA-LSAFA	−0.053	0.438	(−0.20, 0.09)
LSAFA-HUFA	−0.000	0.995	(−0.11, 0.11)
HSAFA-HUFA	−0.052	0.202	(−0.14, 0.03)
PAI activity, *kU/L*			
HSAFA-LSAFA	−0.010	0.793	(−0.09, 0.07)
LSAFA-HUFA	−0.026	0.301	(−0.08, 0.03)
HSAFA-HUFA	−0.036	0.229	(−0.10, 0.03)
tPA antigen, *μg/L*			
HSAFA-LSAFA	−0.010	1.000	(−0.07, 0.05)
LSAFA-HUFA	−0.019	0.894	(−0.07, 0.03)
HSAFA-HUFA	−0.029	0.020	(−0.05, −0.004)
tPA-activity, *kIU/L*			
HSAFA-LSAFA	0.015	0.714	(−0.07, 0.10)
LSAFA-HUFA	0.011	0.565	(−0.03, 0.05)
HSAFA-HUFA	0.025	0.626	(−0.08, 0.14)

[1] All data were log-transformed for ANOVA.

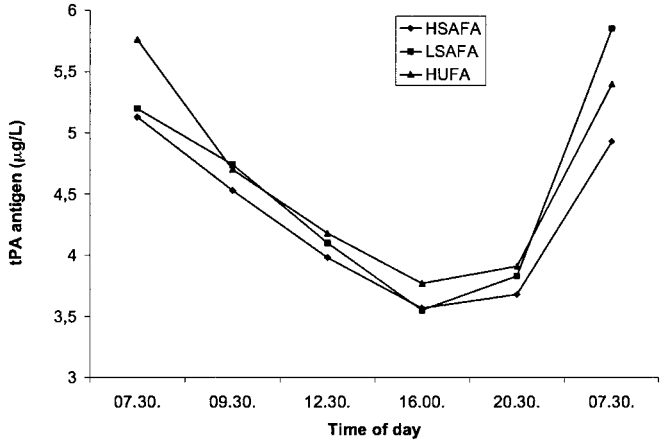

FIGURE 1 Diurnal variation in plasma tissue plasminogen activator (t-PA) antigen in women after consumption of a high fat diet rich in saturated fatty acids (HSAFA), a low fat diet rich in saturated fatty acids (LSAFA) and a high fat diet rich in unsaturated fatty acids (HUFA) for 3 wk. Values are means, $n = 11$.

TABLE 5

Fasting Factor VII and lipoprotein (a) [Lp(a)] concentrations in women at baseline and after consumption of a high fat diet rich in saturated fatty acids (HSAFA), a low fat diet rich in saturated fatty acids (LSAFA) and a high fat diet rich in unsaturated fatty acids (HUFA) each for 3 wk[1]

	Baseline	HSAFA-diet	LSAFA-diet	HUFA-diet
Factor VII, %	107.7 ± 28	114.2 ± 23	110.5 ± 23	113.0 ± 24
Lp(a), *mg/L*	333 ± 451	316 ± 487*	340 ± 493[2]	358 ± 515*[2]

[1] Values are means ± SD, $n = 25$. * Means differ $P < 0.001$.
[2] $P = 0.052$.

study volunteered to participate. Therefore, we cannot exclude the possibility of selection bias.

Postprandial diurnal variations in fibrinogen and FVIIc did not differ among the women consuming the three diets with the laboratory methods used. Previous studies have shown that total fat content and not dietary fatty acid composition influences the level of fasting FVIIc (2,4,5,7,10,35). In our study both the fasting concentration ($n = 25$) and postprandial diurnal variation in FVIIc ($n = 11$) were not influenced by dietary fatty acid composition. Conflicting results exist in the literature. Some studies (36,37), but not all (38,39) showed that postprandial diurnal levels of FVIIc rise after high fat meals compared with low fat meals. Furthermore, in the study of Sanders et al. (37), dietary fatty acid composition was shown to influence postprandial levels of FVIIc.

The clinical implications of reduced fibrinolysis in relation to cardiovascular disease (CVD) are controversial (27,40–45). Several epidemiologic studies have shown reduced fibrinolysis to be associated with an increased risk of CVD or myocardial infarction through reduced plasma levels of t-PA activity (40,41), increased t-PA antigen (43) and PAI-I activity levels (42).

Prospective clinical studies of angina pectoris and postinfarction patients have shown that patients with high t-PA antigen concentrations or low t-PA activity are at higher risk of myocardial reinfarction (42,44). Ridker et al. (27) raised the possibility that t-PA antigen may be a risk factor for atherosclerotic CVD. They also suggested that an increase in t-PA antigen might be a marker for significant atherosclerosis among symptom-free individuals (27). In a prospective multicenter study of 3043 patients with angina pectoris who underwent coronary angiography and were followed for 2 y, t-PA antigen was shown independently to predict subsequent acute coronary syndromes (43).

In the present study, both the HSAFA- and the LSAFA-diets had a lowering effect on Lp(a) compared with the HUFA-diet. This is in accordance with results of several previous studies (14–16). A test fat high in stearic acid significantly increased Lp(a) levels compared with fats in palmitic and myristic + lauric acid (17). It has been suggested that the fatty acids 12:0, 14:0 and 16:0 reduce the levels of Lp(a), whereas 18:0 increases Lp(a) (15,17). In the study of Ginsberg et al. (15), Lp(a) gradually increased after a reduced quantity of saturated fat was recorded. This might be explained by an increasing proportion of 18:0 when saturated fatty acids were reduced. The results of a Finnish study with a diet containing 9.3 E% stearic acid and one containing 8.7 E% from *trans* fatty acids showed an increase in Lp(a) with consumption of both diets compared with a baseline diet (46). In our study, the difference in the content of 18:0 between the HSAFA- and the LSAFA-diet was only 1.3%. The levels of Lp(a) were significantly reduced (13.3%) in those consuming HSAFA and tended to be reduced (5.3%) in those consuming the LSAFA-diets, compared with the HUFA-diet, indicating that it is not only the decrease in 18:0 that explains the reduction in Lp(a). The difference in energy derived from saturated fat (coconut oil) from 10.5 (LSAFA) to 22.7E% (HSAFA) with no change in the P/S ratio did not affect Lp(a) in those consuming the two diets. Another study showed that a short-term intervention with a high complex carbohydrate, low fat diet compared with a baseline Western diet did not affect the level of Lp(a) (8). However, in that study, the P/S ratio of the low fat diet differed from that of the baseline diet (8); thus, their results are not quite comparable with ours. To the best of our knowledge, this controlled study is the first to examine the effect of high saturated fat on Lp(a) in a direct comparison with low saturated fat and no change in the P/S ratio. Nor did we find any significant differences in the level of total or LDL cholesterol between these two diets (21).

The connection between Lp(a) and atherosclerosis is not entirely understood. Different studies have provided strong evidence that Lp(a) level is an independent risk factor for developing coronary artery disease in men (47,48), but the question of causality continues to be debated. Recent data suggest that Lp(a) might be atherogenic (49), in particular when combined with other risk factors. High levels of Lp(a) combined with other risk factors such as the ratio of plasma total/HDL cholesterol have been shown to increase the risk for coronary heart diseases (50). It has also been reported that when substantial LDL cholesterol reductions were obtained in men with coronary heart disease, persistent elevations of Lp(a) were no longer atherogenic or clinically threatening (51).

In conclusion, the present results show that the HSAFA-diet lowered postprandial t-PA antigen and thus potentially improved fibrinolysis compared with the HUFA-diet. Diets with either high or low levels of saturated fatty acids from coconut oil beneficially decrease Lp(a) compared with a HUFA-diet. The proportions of dietary saturated fatty acids more than the percentage of saturated fat energy may be of importance if the goal is to decrease Lp(a).

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