Palmitic acid effect on lipoprotein profiles and endogenous cholesterol synthesis or clearance in humans

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The effect of palmitic acid (C16:0) on serum lipoprotein cholesterol levels is debatable. If C16:0 is hypercholesterolaemic, then it may increase the endogenous synthesis or decrease clearance of cholesterol. Four diets were formulated to provide combinations of two levels of C16:0 in relation to two levels of PUFA. Healthy male subjects received each of the four diet treatments for 21 days, followed by washout periods of 21 days. On day 21 of each diet treatment, a fasting blood sample was drawn for lipoprotein determination and to provide a measure of the background level of deuterium. A priming dose of deuterium was consumed and a second blood sample obtained 24 hours after the first sample. Isotope Ratio Mass Spectrometry was used to determine the incorporation of deuterium into the newly synthesised cholesterol molecule, and fractional synthetic rates calculated. Serum total cholesterol and LDL-cholesterol was not significantly affected by the high level of C16:0 when diets also contained the high level of PUFA. There was no effect of C16:0 on HDL-cholesterol at either the high or low levels of intake. The fractional synthetic rates of cholesterol observed for each of the diet treatments did not significantly differ from one another, suggesting no relationship between the endogenous synthesis of cholesterol and diet C16:0 content. These results indicate that C16:0 had no effect on serum lipoprotein profiles in the presence of recommended intakes for PUFA, nor did it increase rates of cholesterol synthesis in healthy males.

Key words: Lipidaemia, fat intake, palmitic acid

Introduction

Specific dietary saturated fatty acids may raise total cholesterol levels, and specifically LDL-cholesterol levels. However, the effects of individual saturated fatty acids are complicated by evidence showing that all saturated fats do not affect lipoprotein profiles equally[1-3]. Stearic acid has little effect on plasma lipid levels, exerting a neutral effect similar to that of some mono-unsaturates, while lauric and myristic acid-rich fats have potent cholesterol-raising effects[4-6].

The principal dietary saturated fatty acid is palmitic acid. Palmitic acid is the major saturate in animal fats, occurring in large proportions in both meat and dairy products, as well as contributing substantially to both palm and cottonseed oil[6,7]. The earlier studies that involved palmitic acid identified this saturate as exerting a significant hypercholesterolaemic effect[8,9]. However, these findings have recently been questioned by a number of researchers. Thus the hypercholesterolaemic effect of palmitic acid is debatable.

In a controlled metabolic feeding study Tholstrup *et al* investigated the effects of three diets differing in the major fatty acid supplied (stearic, palmitic or myristic plus lauric)[10]. It was concluded that the cholesterol-raising properties of saturated fats could be attributed solely to lauric, myristic and palmitic acid. The effect of palmitic acid on cholesterol levels was approximately midway between that of the other saturates. These results parallel those suggested by both Keys and Hegsted nearly 30 years earlier in their regression equations used to predict serum cholesterol responses to various fatty acids[9,11]. According to the original Keys hypothesis, palmitic acid should increase blood cholesterol levels. However, these commonly cited equations failed to separate the effect of three saturated fatty acids (12:0, 14:0 and 16:0), defining these as equally hypercholesterolaemic. In fact, when the Keys equation is modified to treat palmitic acid as neutral (similar to stearic acid), the equation is a better predictor of changes observed in serum cholesterol levels. This observation has been supported by Hayes, who hypothesised that 16:0 can be a neutral fatty acid[12]. In a study which exchanged 5% of energy from 12:0 plus 14:0 for 16:0 in healthy young men consuming a low cholesterol diet, the dietary combination of 12:0 plus 14:0 produced significantly higher serum cholesterol levels than did 16:0[13].

Studies which have identified palmitic acid as a cholesterol raising saturate have focused on the effect of palmitic acid on the LDL-cholesterol fraction. It has been suggested that palmitic acid may suppress expression of LDL receptors, or accelerate VLDL secretion from liver to elevate plasma LDL-cholesterol[14]. Evidence also suggests that palmitic acid may enhance HDL-cholesterol production. Lindsey *et al* examined the qualitative effects of specific fatty acids on plasma lipoprotein metabolism by feeding six, low-fat, cholesterol-free diets to hamsters for four weeks each[15]. The fat blends differed only in their source of fat; coconut oil, palm oil, soybean oil, safflower oil, butter, corn oil, and canola oil. In three of the diets, the PUFA/MUFA/SFA ratio was held constant while the lauric, myristic and palmitic acid level was varied. Replacing lauric acid plus myristic acid from coconut oil with palm oil induced a significant increase in HDL-cholesterol and a slight decrease in LDL cholesterol. Based on this observation it has been suggested that if palmitic acid raises serum cholesterol it may exert this effect by increasing the concentration of the lipoprotein fraction known to favourably impact atherogenesis, ie HDL.

The controversial role of dietary palmitic acid is further compounded by other researchers who have failed to demonstrate elevated plasma cholesterol following palmitic acid consumption. Ng *et al*, compared the effects of palmitic acid and oleic acid in normocholesterolaemic subjects[16]. Prior to being assigned to either a palm oil rich diet or an olive oil rich diet, subjects were challenged with a diet high in coconut oil. This test diet, as expected, significantly raised all the serum lipoproteins. However, exchanging 7% of energy between palm oil and olive oil produced identical lipoprotein profiles, leading to the conclusion that in healthy humans, exchanging palmitic acid for oleic acid within the range of these fatty acids normally present in a typical diet will not effect the serum cholesterol concentration.

The mechanism by which specific fatty acids exert a hypercholesterolaemic effect has been the subject of much debate. Changes in faecal sterol excretion and alterations in exogenous

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cholesterol absorption have been proposed as mechanisms by which specific saturated fatty acids raise plasma cholesterol levels, but neither can be definitively linked to changes observed following dietary fat modifications[17-21]. Alterations in lipoprotein composition and uptake may be partially responsible for changes observed in serum lipid levels, but are unlikely to affect overall cholesterol balance[22-24]. Endogenous cholesterol synthesis appears to be affected by the quality of the dietary fat fed and may therefore be the key determinant of plasma cholesterol levels in humans[25,26]. Although such a relationship has been defined in animal models, this relationship in humans has not been thoroughly investigated, primarily due to lack of a suitable biosynthetic precursor. The majority of previous studies have assessed rates of cholesterol synthesis through a variety of *in vitro* and *in vivo* techniques including assay of activity of rate limiting enzymes in cholesterol biosynthesis and assay of rates of incorporation of various [14C] substrates into cholesterol. Although both techniques provide a measure of the relative rates of cholesterol synthesis in a specific organ, neither technique provides data in which absolute rates of cholesterol synthesis can be calculated[27,28]. Furthermore, techniques which employ [14C] substrates necessitate that the labelled substrate be metabolised to [14C] acetyl CoA, resulting in dilution by that of unlabeled acetyl CoA which enters from other substrates. Consequently, the calculated rates of cholesterol synthesis have been underestimated. More recent studies have identified that the use of water incorporation techniques for measuring rates of cholesterol synthesis are superior to the [14C] substrate method[29]. Since the specific activity of cell water is constant in all tissues in the body, a reliable determination of cholesterol synthesis can be made. Recent advances in isotope ratio mass spectrometry have further improved the quantitation of endogenous rates of cholesterol synthesis. This technique allows for use of small amounts of deuterium in metabolic studies which previously required radioactive substances with undesirable side effects and limitations in their uses[30].

This study investigated the relationship between dietary palmitic acid levels fed in high or low linoleic acid diets and the rate of endogenous synthesis of cholesterol in relation to plasma cholesterol levels. Using the deuterium-uptake method the fractional synthetic rate of cholesterol was assessed in response to diets varying in palmitic acid content. Lipoprotein cholesterol level profiles were also determined to characterise the impact of dietary palmitic acid on blood lipids.

Methods

Subjects. A total of six healthy, male volunteers aged 24.0 ± 4.7 years (range 20-32 years) were recruited by advertisements at the University of Alberta, Canada. Subjects were 182.4 ± 4.4 cm (mean ± SD) with a body mass index (BMI) of 23.4 ± 3.5 (Table 1). Average energy intakes of the subjects was 3500 ± 210 kcal/d (14.7± 0.9 MJ/d). Subjects were screened by questionnaire for chronic disease, sleeping habits and exercise schedules. Subjects reported no history of significant medical or metabolic diseases, were non-smokers, were taking no medications or vitamin supplements and denied having a family history of diabetes or coronary artery disease. The protocol was approved by the Ethics Review Committee at the University of Alberta. Subjects gave informed consent prior to the investigation.

Table 1. Demographic parameters and weight of subjects during diet treatments.

Subject	Age (y)	Height (cm)	Intake (kcal)	mean wt (kg)	BMI
1	20	175.3	3400	66.7	21.7
2	32	180	3200	68.0	21.0
3	26	185.4	3400	69.2	20.1
4	21	182.9	3600	74.3	22.2
5	25	182.9	3800	112.9	33.8
6	20	188	3600	75.6	21.4
mean	**24.0**	**182.4**	**3500.0**	**77.8**	**23.4**
std dev	**4.7**	**4.4**	**209.8**	**17.6**	**3.5**

Protocol. The study consisted of four diet treatments of 21 days each, followed by washout periods of at least 21 days. Four of the six subjects underwent each of the four, three-week diet treatments, and the remaining two subjects completed only three of the four diet treatments. Each diet treatment was comprised of a three-day rotational menu partitioned into three isocaloric meals. Diets were formulated based on normal foods to provide the following high (approximately 10-12% of kcal) or low (approximately 3% of kcal) combinations of C16:0 (palmitic acid) in relation to C18:2 (linoleic acid): low C16:0, low C18:2; low C16:0, high C18:2; high C16:0, low C18:2 and high C16:0, high C18:2 (Table 2). Meals for each diet were provided by the Metabolic Research kitchen for consumption on site (breakfast and lunch) or packaged for take-out (supper). Meals were consumed at regular intervals; 0800-0900h, 1130-1300h, and 1730-1900h for breakfast, lunch and supper respectively depending on the individual subjects schedules. Supplementary foods were not permitted during the study except for clear tea, decaffeinated coffee or other energy/caffeine free beverages. Caloric intake of each subject was tailored to individual requirements based on the Harris-Benedict equation and incorporating an activity coefficient between 1.7 and 2.0 depending on the individual degree of activity. Subjects were weighed daily before breakfast to verify maintenance of stable body weight. Diets were formulated based on the Food Processor II nutrient analysis computer software program and fatty acid content from published nutrient composition tables to contain an average of 28.9 ± 1.6% energy as fat (range of 27.6-31.1% of total kcals), 16.3 ± 0.5% energy as protein (range of 15.7-16.9% of total kcals) and 56.2 ± 1.9% energy as carbohydrate (range of 53.5-57.8% of total kcals) (Table 2). Diets were analysed to verify the fatty acid composition actually fed. Each diet treatment was balanced for omega-3 fatty acids, cholesterol and fibre content.

Table 2: Nutrient composition of diets [1]

Nutrient	Low C16:0 Low C18:2	Low C16:0 High C18:2	High C16:0 Low C18:2	High C16:0 High C18:2
calories (kcal)	3073.7 ± 158.2	2991.0 ± 267.8	3027.7 ± 31.7	2988.3 ± 228.0
protein (%kcal)	15.7 ± 3.1	16.9 ± 2.3	16.3 ± 0.4	16.1 ± 2.1
carbohydrate (%kcal)	56.5 ± 4.8	57.0 ± 3.3	57.8 ± 0.8	53.5 ± 2.6
total fat (%kcal)	29.2 ± 1.7	27.6 ± 1.1	27.8 ± 0.1	31.1 ± 0.5
saturated fat (%kcal)	4.8 ± 0.7	4.7 ± 0.3	13.9 ± 0.6	10.2 ± 0.7
MUFA (%kcal)	18.8 ± 0.9	7.5 ± 0.1	9.0 ± 0.2	8.1 ± 0.3
C18:2 n-6 (%kcal)	2.8 ± 0.6	12.0 ± 1.4	2.0 ± 0.2	12.1 ± 0.6
C16:0 (%kcal)	3.2 ± 0.2	2.9 ± 0.2	10.1 ± 0.4	9.9 ± 0.2
n-3 FA (%kcal)	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.40 ± 0.0
cholesterol (mg)	200.0 ± 20.8	176.7 ± 77.5	208.0 ± 57.4	148.8 ± 22.5
dietary fibre (g)	27.1 ± 6.0	32.7 ± 8.5	28.0 ± 5.1	31.9 ± 5.3

[1] Values represent means ± SD; n=3 for each diet treatment. Diet averages are based on the average nutrients calculated from each menu cycle for a given diet. All values are derived from Food Processor II data except for C16:0 and C18:2 n-6 which are derived from published food composition tables

Between 0715 and 0830h on day 21 of each diet phase, a fasting blood sample was obtained by venipuncture (30 mL) and subjects consumed a priming dose of 0.5g D_2O/kg estimated total body water (99.8 atom percent excess, ICN Biomedicals, Montreal, Canada) prior to breakfast. Total body water was estimated as 60% of body weight (taken as the average over each of the 21 day feeding period). A 2 litre bottle of water containing 1.0g D2O/kg estimated total body water was provided for consumption over the next 24 hour period to maintain plasma deuterium enrichment at plateau and to compensate for unlabeled water obtained in the diet. At 24 hours after the first sample, a second fasting blood sample (25 mL) was obtained. Plasma was obtained by centrifugation at 3000 rpm and frozen at -20°C. Plasma (5 mL) was sent to the University of Alberta Hospitals for total cholesterol, LDL-C, HDL-C, and creatinine determination. Total cholesterol content was determined enzymatically.[31] HDL was determined following precipitation of other lipoproteins using dextran sulphate magnesium as described.[32] LDL cholesterol levels were calculated by subtracting HDL cholesterol from the cholesterol level of 1.006 $g \cdot ml^{-1}$ infranatant fraction. Serum creatinine levels were determined by the kinetic Jaffe reaction.[33, 34]

Fat analysis of diets. Duplicate freeze-dried preparations of each complete meal cycle for each diet phase were homogenised in a polytron, aliquoted (10 g samples) and stored at -20°C until analysed for total fat and fatty acid content. Fat extraction[35] was carried out prior to saponification and transesterification with KOH and boron triflouride methanol reagent.[36] Fatty acid methyl esters were analysed by gas liquid chromatography (Vista 6010 GLC and Vista 402 data system; Varian Instruments, Georgetown, Ontario) as described previously.[36] Fatty acid methyl esters were identified by comparison of retention data with that of authentic standards and quantitated by peak area comparison with internal standards.

Determination of deuterium enrichment. Deuterium enrichment was measured in plasma water, plasma cholesterol and plasma cholesteryl ester. To extract the free and esterified cholesterol, 2 mL of plasma at each time point was combined with 4 mL of methanol and heated at 55°C for 15 min. 12 mL of a 4:1 hexane:chloroform solution (v/v) was added and shaken mechanically for 10 min. 1 mL of water was added and the mixture shaken again. Centrifugation at 1500 g for 15 min. was followed by removal of the upper hexane:chloroform phase. This process was repeated, upper phases combined, and solvent removed under nitrogen. Extracts were redissolved in 200 µL chloroform and spotted onto thin-layer silica G plates (Analtech Inc., Newark, DE). Plates were developed using petroleum ether-diethyl ether-acetic acid (80:20:1, v/v/v) and air dried. Lipid fractions were identified by comparison with a standard (Supelco, Bellefonte, PA). Free and esterified cholesterol bands were scraped from the plates and eluted from the silica scrapings three times using hexane-chloroform-diethyl ether 5:2:1 (v/v/v), and dried under nitrogen. Cholesteryl ester fractions were saponified in 0.5N KOH in methanol for two hours in a sand bath and the resultant free cholesterol was purified by thin layer chromatography as before. The saponification step was repeated once more with the cholesteryl ester band and the free cholesterol pooled with the previous pellet. After two saponifications, no further cholesteryl ester could be converted to free cholesterol. The dried cholesterol sample was transferred to a 1 x 10 mm Pyrex tube, using three washes of chloroform. Cupric oxide wire (0.5 g) and a 2.5 cm-length 1 mm silver foil was added to the tube. The tube was placed inside a 15 x 9 mm Pyrex (Corning Glass Works, Corning, NY) sealed at one end. Combustion tubes were evacuated to less than 50 mtorr before being sealed with a hot flame. Tubes were placed in an oven at 51° C for four hours to combust the cholesterol to carbon dioxide and water. After cooling in the furnace overnight, the tubes were attached to a vacuum manifold by means of flexible tubing between Cajon fittings (Swagelok Canada Ltd, Niagra Falls, Ontario) and the seal was broken by flexing the tube. The combustion product water was transferred by vacuum distillation into a second Pyrex tube containing 60 mg of zinc reagent.

Samples of day 22 plasma (enriched plasma), intended for plasma water enrichment measurement were diluted twenty-fold with 5% bovine serum albumin solution to lower the deuterium enrichment to within the analytical range of the instrument. Baseline plasma samples were not diluted. Plasma water samples (10 µL) were distilled into Pyrex tubes containing zinc. The water samples from plasma water and combustion of cholesterol were reduced by zinc to hydrogen gas by placing the reaction tubes in a heating block at 470° C for 30 min.[37] The reaction tubes could be attached directly to the mass spectrometer without further purification. The deuterium enrichment was measured by use of a Finnigan MAT 251 Isotope Ratio Mass Spectrometer (Bremen, Germany) against hydrogen prepared from a water standard. The mass three abundance was corrected for H_3^+ contribution. Multiple analyses of hydrogen produced from the reduction of a laboratory water standard demonstrated the analytical precision (coefficient of variation) of this instrument at <1%. All samples were analysed in duplicate.

Cholesterol fractional synthesis rates (FSR) were determined from the initial incorporation rate of deuterium-labelled cholesterol into the rapidly exchangeable cholesterol pool, relative to the initial precursor enrichment as determined using the body water deuterium level.[27] Maximum attainable enrichment was calculated as the body water pool enrichment corrected for the fraction of protons in de novo synthesised cholesterol that derive from water, relative to non-water sources using the equation:

$$FSR\ (d^{-1}) = \frac{del\ (^0/_{00})_{init}\ cholesterol}{del\ (^0/_{00})\ plasma\ water}$$

where del_{init} refers to the difference in plasma cholesterol deuterium enrichment the initial 24 h, and $del_{max\text{-}init}$ the maximum initial enrichment predicted as del ($^0/_{00}$) plasma water x 0.478.[27-29]

Statistical analysis. Statistical analyses included analysis of variance procedures (SAS Inc, Cary NC, USA). To assess the effect of diet on lipoprotein cholesterol levels the significant difference between diet treatments were determined by a Duncan's multiple range test (Steel and Torrie, 1980). Statistical significance was set at $p<0.05$.

Results and discussion

Subjects. Demographics of study participants is shown (Table 1). By observation of subjects in the metabolic unit, self reports by subjects and the lack of meals returned unfinished indicated that the level of subject compliance in completing meals was high.. Body weight fluctuations by each subject over each 21 day feeding period was negligible (ranging from ± 0.2 to 0.6 kg). Body weight for individuals over the entire study period varied somewhat. The group mean weight change was small (+2.29%) with the majority of weight change occurring during the washout periods. Mean creatinine levels were not significantly different between background and test days for each subject on each diet treatment providing a measure of similar hydration status for each test period (ie, no dilution effect).

Diets. Composition of the diets consumed is shown (Table 2). The contribution of energy from protein, carbohydrate and fat was within 3-4% for each of the macronutrients between diet treatments. There were no significant difference between diet treatments in regard to dietary fibre (29.9 ± 2.8g), omega-3 fatty acid (1.54 ± 0.16mg) and cholesterol (183.4 ± 26.6 mg) content. The arachidonic acid, eicosapentaenoic acid and docosahexaenoic acid was negligible in each of the diet treatments (0.016 ± 0.006%, 0.022 ± 0.012%, and 0.030 ± 0.011% of fatty acids respectively). In diets in which the C16:0 and C18:2n-6 content did not provide most of the required dietary fat, the remainder of

the fat was provided by monounsaturated fatty acids. The analysed fat content of meals in each diet treatment was close to the formulated values, and was consistent within each diet treatment.

Table 3. Lipoprotein cholesterol levels for subjects studied[1]

Main effects of diet treatment	Total-cholesterol	LDL-cholesterol	HDL-cholesterol
Low C16:0	3.19 ± 0.05*	1.79 + 0.04**	1.11 + 0.02***
High C16:0	3.69 ± 0.05	2.22 + 0.04	1.19 + 0.02
Low C18:2	3.53 ± 0.05Ψ	2.08 + 0.04ΨΨ	1.15 + 0.02ΨΨΨ
High C18:2	3.35 ± 0.05	1.94 + 0.04	1.15 + 0.02

[1] values are adjusted means ± pooled SEM
* total chol. significantly different for low C16:0 vs. high C16:0, p<0.0001
Ψ total chol. significantly different for low C18:2 vs. high C18:2, p<0.05
** LDL-chol. significantly different for low C16:0 vs. high C16:0, p<0.0001
ΨΨ LDL-chol. significantly different for low C18:2 vs. high C18:2, p<0.05
*** HDL-chol. significant different for low C16:0 vs. high C16:0, p<0.01

Lipoprotein cholesterol determination. Plasma lipid level response to diet treatment are reported in Table 3. To account for slight differences in the total fat content of each of the diet treatments, lipoprotein values were adjusted by the ratio of dietary fat to average dietary fat intake (Figure 1 a, b and c.)

Total cholesterol. Normal levels of cholesterol for male subjects within the age range studied is 3.20 - 4.60 mmol/L. During the entire study period, normalised total cholesterol values were between 3.17 and 4.02 mmol/L. Feeding high C16:0 increased levels of total cholesterol from 3.30 to 3.61 mmol/L (p<0.0001) when the diet was low in C18:2n-6. When the diet was high in C18:2n-6 raising the level of C16:0 did not have a significant effect on total plasma cholesterol level. The effect of dietary C18:2 was also significant, with diets high in C18:2 producing a lower total cholesterol response (3.31 mmol/L) than diets low in C18:2 (3.59 mmol/L).

LDL cholesterol. The normal range of LDL-cholesterol is between 1.70 and 3.00 mmol/L. Throughout the study period normalised LDL-cholesterol values ranged from 1.76 to 2.48 mmol/L; within the low range of normal. Plasma LDL-cholesterol level was higher (p<0.0001) when subjects consumed the higher level of C16:0 (2.18 mmol/L) at the low C18:2 intake level. LDL-cholesterol levels decreased (p<0.01) at the high levels of C18:2 consumption (1.92 mmol/L) as compared to the lower levels of C18:2 (2.12 mmol/L). Similar to the total cholesterol response, when the diet was high in C18:2 raising the level of C16:0 did not have a significant effect on total plasma LDL-cholesterol levels.

HDL cholesterol. The normal levels of HDL-cholesterol is between 0.90 and 1.60 mmol/L. Throughout the study period, normalised HDL-cholesterol values varied only minimally, ranging from 1.08 to 1.24 mmol/L. Although no significant main effects of diet on HDL-cholesterol levels were observed, at low levels of C18:2, high C16:0 raised HDL-cholesterol levels (1.09 mmol/L vs. 1.24 mmol/L) (p<0.001). Conversely, at high levels of C18:2, high C16:0 lead to significant reductions in HDL-cholesterol levels (1.21 mmol/L vs. 1.08 mmol/L) (p<0.003).

Figure 1a. Total cholesterol for subjects. Values represent mean ± SEM for all subjects. NS= non-significant (p>0.05).

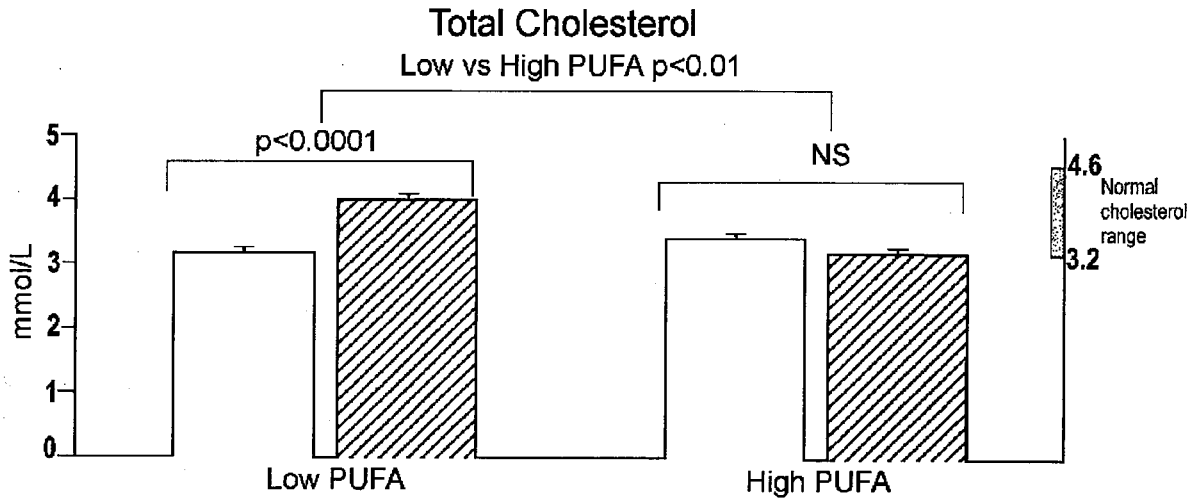


Figure 1b. LDL-cholesterol for subjects. Values represent mean ± SEM for all subjects. NS= non-significant (p>0.05).

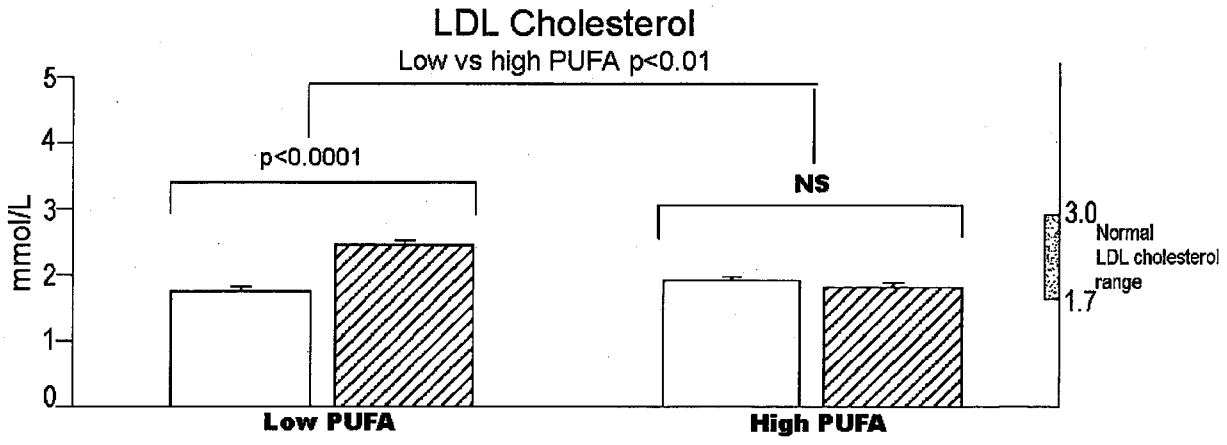


Figure 1c. HDL-cholesterol for subjects. Values represent mean ± SEM for all subjects. NS= non-significant (p>0.05).

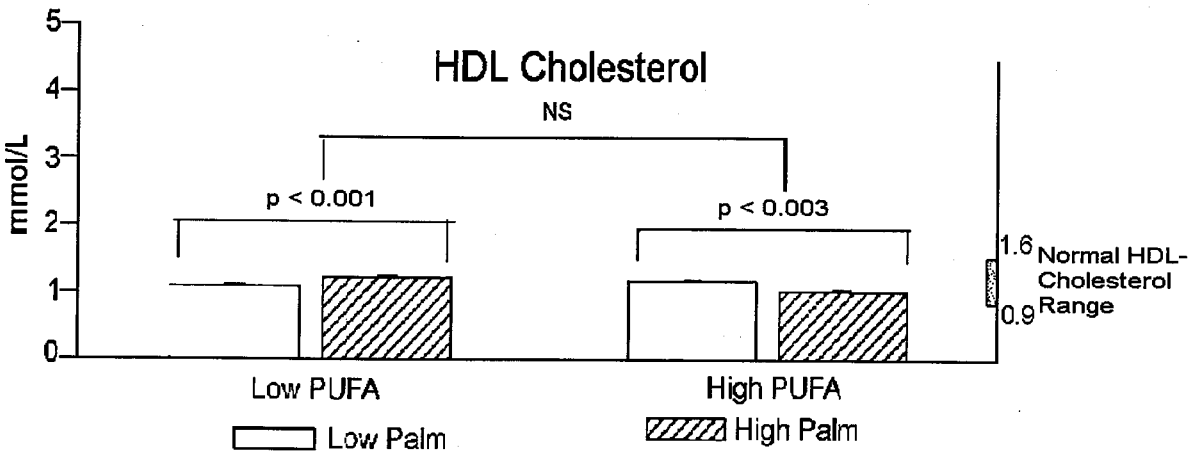
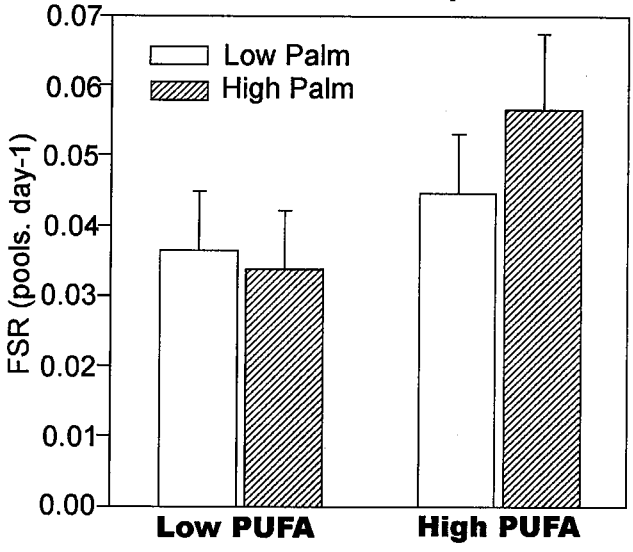


Figure 2. Fractional synthesis rate (FSR) for total plasma cholesterol in subjects consuming the following diets: Low C16:0, Low PUFA (n=5); Low C16:0, High PUFA (n=5); High C16:0, Low PUFA (n=5); High C16:0, High PUFA (n=3). Diet fat effect non-significant at p<0.05. Values are means ± pooled SEM.



For each of the diet treatments, the mean total cholesterol, LDL-cholesterol and HDL-cholesterol for subjects was maintained within normal ranges. The highest total and LDL-cholesterol response occurred following consumption of the high C16:0, low C18:2 combination, and the lowest following the low C16:0, low C18:2 combination. However, the diet combination of high C16:0 with high C18:2 resulted in a total cholesterol response very similar to that of the low C16:0; low C18:2 diet (3.20 mmol/L vs. 3.17 mmol/L). This data suggests that in the presence of adequate C18:2, palmitic acid has minimal effect on lipoprotein levels.

Fractional synthetic rate. Effect of diet on cholesterol FSR values is shown in Fig. 2. Values for FSR were not significantly affected by either the C16:0 or C18:2 content of the diet. This data suggests that palmitic acid does not influence endogenous cholesterol synthesis for subjects who have cholesterol values within the normal range. While no significant differences occur in the FSR for cholesterol, it appears that larger FSR values occur in the individual subjects who exhibit a greater change in serum cholesterol values in response to diet treatment. This relationship, unlike that of the lipoprotein response, appears to be independent of the dietary linoleic acid level.

Current dietary recommendations suggest no more than 30% of total calories be derived from fat. Of this, at least one-third, or 10% of calories, is suggested to be obtained from PUFA. The diets in this study designated high in linoleic acid contained PUFA at the levels currently recommended. At this linoleic acid content palmitic acid had no significant effect on the total cholesterol and LDL-cholesterol subfraction. This data suggests that the cholesterol raising potential of palmitic acid is dependent on the linoleic acid level in the diet. This finding may have important applications to the food industry in that the favourable properties of palm olein in combination with a good source of linoleic acid can be exploited without expecting adverse effects on serum lipoprotein cholesterol content.

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Palmitic acid effect on lipoprotein profiles and endogenous cholesterol synthesis or clearance in humans
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棕櫚酸對脂蛋白和内源性膽固醇在人體内合成的影響

摘要

棕櫚酸〔C16:0〕對血清脂蛋白膽固醇水平的影響仍有爭論，如果棕櫚酸可引起高膽固醇血症，那么它一定會增加内源性膽固醇的合成。作者按配方制成四種試驗膳食，兩種含不同水平的C16: 0〔高及低〕和兩種含不同水平的PUFA〔高及低〕。用這四種膳食給予四位健康男性服用21天。在轉換膳食前，至少有21天清洗期。每次在進食試驗性膳食的第21天，均抽取空腹血液測定脂蛋白和重氫，然后給予一定劑量的重氫，24小時后再抽取第二次血液，用同位素質譜儀測定新合成人膽固醇内的重氫，并計算部分合成率。結果顯示當膳食含高水平的PUFA時，血清總膽固醇和低密度脂蛋白膽固醇不受高C16: 0膳食的影響。在進食高或低C16: 0膳食時對高密度脂蛋白膽固醇濃度没有影響。作者觀察到四種膳食對膽固醇的部分合成率的影響没有明顯差异。提示了内源性膽固醇合成與C16: 0水平無關。這些結果指出了在目前進食的PUFA水平下，C16: 0對血清脂蛋白不發生影響，亦不會增加健康男性的膽固醇合成率。