

## Review article

## Butter, margarine and serum lipoproteins

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**Abstract**

Intake of *trans* fatty acids unfavorably affects blood lipoproteins. As margarines are a major source of *trans*, claims for the advantages of margarines over butter need to be scrutinized. Here we review dietary trials that directly compared the effects of butter and margarine on blood lipids. We identified 20 studies in which subjects had stable body weights, and margarine and butter were exchanged in the diet at constant energy and fat intake. We calculated the changes in average blood lipid levels between study diets (49 comparisons) as a function of the percentage of calories as margarine substituted for butter. Replacing 10% of calories from butter by hard high-*trans* stick margarines lowered total serum cholesterol by 0.19, LDL by 0.11, and HDL by 0.02 mmol/l, and did not affect the total/HDL cholesterol ratio. Soft low-*trans* tub margarines decreased total cholesterol by 0.25 and LDL by 0.20 mmol/l, did not affect HDL, and decreased the total/HDL cholesterol ratio by 0.20. Based on the total/HDL cholesterol ratio, replacement of 30 g of butter per day by soft tub margarines would theoretically predict a reduction in coronary heart disease risk of 10%, while replacement of butter by hard, high-*trans* margarines would have no effect. Replacing butter by low-*trans* soft margarines favorably affects the blood lipoprotein profile and may reduce the predicted risk of coronary heart disease, but high-*trans* hard margarines probably confer no benefit over butter. © 1997 Elsevier Science Ireland Ltd.

**Keywords:** Butter; Margarine; Dietary fatty acids; Lipoprotein cholesterol; Humans; Coronary heart disease

**1. Introduction**

Hypercholesterolemia affects large numbers of people in affluent and increasingly also in developing countries. Diets low in saturated fat have long been the first line of treatment, especially for moderately elevated cholesterol levels. A standard feature of such diets is restricting the intake of butter and milk fat, and partly replacing them by fats of vegetable origin, including margarines. However, new findings on the effects of

*trans* fatty acids on blood lipoproteins have thrown doubts on the value of margarines for improving the lipoprotein risk profile. Dietary *trans* fatty acids raise LDL cholesterol and lower HDL cholesterol in humans [1–3]. Some [4–7], but not all [8,9], epidemiologic studies also indicate that high intakes of *trans* fatty acids increase coronary heart disease (CHD) risk. Margarines have long had a ‘healthy’ image because they are lower in saturated fatty acids and cholesterol than butter. However, some margarines are also rich in *trans* fatty acids. As a result the putative health benefits of margarine need to be reassessed [10–13]. Here we review the effects of butter and margarine on lipoprotein cholesterol concentrations as risk factors for coronary heart disease.

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## 2. Methods

### 2.1. Selection of studies

We screened MEDLINE (1966–1995), Biological Abstracts (1991–1995), and reference lists of pertinent articles and reports for experimental studies of the effects of butter, dairy or milk fat, margarine, or hardened or (partially) hydrogenated fat. Twenty-eight studies directly compared the effects of butter and margarine on blood lipids in humans.

We selected studies in which subjects had stable body weights, at least two-thirds of the intervention consisted of exchanging margarine isocalorically for butter and dairy fats, and in which differences in total fat or carbohydrates between the margarine and the butter diets made up less than 3% of energy intake. This yielded 20 studies [3,14–32] which provided 49 dietary comparisons (Table 1). Twelve were metabolic-ward trials in which all food was provided, and eight employed free-living subjects who were provided with the fats under investigation. Experimental diets were consumed for 8–175 days, and margarine or butter provided between 5 and 45% of total caloric intake.

We classified the margarines as hard (stick or wrapper) or soft (tub). Most studies used commercial margarines, but some also investigated fat blends suitable for margarine production. The majority of the margarines were made of partially hydrogenated or unmodified vegetable oils. The remainder contained lard, tallow, or partially hydrogenated fish or whale oil (Table 1).

Missing information on dietary intervention and the fatty acid composition of the margarines was obtained from the authors [25,28,29] or was estimated from data on commercial margarines that were current at the time of the study in question [17,19,26].

### 2.2. Data analysis

We calculated the changes in serum or plasma total, LDL, and HDL cholesterol levels, in the ratio of total to HDL cholesterol, and in triglyceride levels as a function of the amount of margarine exchanged for butter (percentage of total caloric intake). Regression analyses were performed using the General Linear Models (GLM) procedure of the SAS package [33]. For cross-over and sequential designs we subtracted the mean level at the end of the margarine period from that at the end of the butter period. For parallel studies, we calculated the difference between the changes on the two treatments. Exchanging margarine for butter comprised on average 97% of calories of the total dietary intervention. For cross-over and parallel studies, the observed changes could be fully attributed to the replacement of butter by margarine, because the study design eliminates drift of variables over time. For se-

quential designs, spurious changes may be observed because subjects' lipid levels may decrease when they participate in dietary trials, regardless the nature of the dietary intervention. However, of the 13 comparisons with a sequential design (Table 1), seven first supplied the margarine diet and then the butter diet, and the other six first supplied the butter diet. As a result, the effect of drifts of lipid and lipoprotein levels with time on the difference between margarine and butter probably averaged out in the combined estimates. Thus, changes were almost completely attributable to the dietary fats themselves, and zero substitution should produce no change. Therefore, regression lines were forced through the origin.

In analyses of the relation between changes in lipoprotein cholesterol levels and *trans* and saturated fatty acid content, regression lines were not forced through the origin, because other aspects of the margarines, e.g. content of other fatty acids or cholesterol, may vary and affect lipoprotein levels independent of the *trans* or saturated fatty acid content.

The number of subjects varied among the trials. To take this into account, it is usual in meta-analyses to weight each study by the reciprocal of the squared standard error. Most studies did not report the standard error of the differences in lipoprotein levels between subjects on butter and on margarine. We therefore weighted by the square root of the number of subjects, which is inversely proportional to the standard error. This yielded results essentially similar to those obtained by unweighted analysis; therefore we present only unweighted results.

## 3. Results

Twenty studies comprising 49 comparisons of butter and margarine met our criteria. These were published between 1957 and 1995 (Table 1). Most studies provided one or two dietary comparisons, but de Jongh et al. provided five [22], and Beveridge et al. 16 [20]. Ten studies published between 1980 and 1995 and comprising 15 dietary comparisons provided data on HDL cholesterol.

In 32 comparisons involving a total of 402 subjects hard stick or 'brick' margarine was used; the other 17 comparisons, involving 939 subjects, used soft tub margarines. In five comparisons margarine containing partially hydrogenated fish oils was used. Fig. 1 shows the average composition of butter and of the margarines in the studies reviewed here. Butter contains on average 51 g saturated, 3 g *trans*, 21 g *cis*-monounsaturated, and 2 g of *cis*-polyunsaturated fatty acids per 100g. The margarines on average contained 20 g saturated, 18 g *trans* (range 0–39 g), 22 g *cis*-monounsaturated, and 18 g of *cis*-polyunsaturated fatty acids per 100 g of

Table 1  
Overview of studies that compared effects of margarine versus butter on serum lipids in humans

First author and year	N	Design and setting <sup>a</sup>	Days	Margarine	Type <sup>b</sup>	Trans content (g/100g)	Amount ( % calories ex-changed)	Difference in plasma cholesterol (margarine minus butter, mmol/l)		
								Total	LDL	HDL
Keys [14] 1957	18	//, controlled, 5–7/arm	11	A: Hard, comm, fish, B: Hard, comm, veg	13 14	11	+0.04 -0.09	+0.12 +0.12		
Horlick [15] 1960	4	Linear, controlled, 2 subjects	8	A: Soft, expt, veg B: Hard, comm, veg	12 20	40	-0.91 -0.26			
Anderson [16] 1961	23	X, controlled	21	Hard, expt, veg	38	31	-0.62			
Wilcox [17] 1961	8	Linear, controlled	15	Hard, comm, veg	24	27	-1.22			
Antonis [18] 1962	36	//, controlled, 18–20/arm	175	Hard, expt, veg	24	25	-0.88	-0.70		
Morse [19] 1962	12	//, controlled, 4/arm	42	A: Hard, comm, veg B: Soft, comm, veg	20 12	37	-1.40 -1.40			
Beveridge [20] 1962 moderate amount of margarine	88	//, controlled, ca. 9/arm	8	A: Soft, comm, veg B: Hard, comm, veg C: Hard, comm, veg D: Hard, comm, veg E: Hard, comm, veg F: Hard, comm, lard G: Hard, comm, veg H: Hard, comm, lard	17 32 25 28 22 17 34 24	22.5	-0.35 -0.48 -0.51 -0.39 -0.60 -0.35 -0.59 -0.58			
Beveridge [20] 1962 high amount of margarine	91	//, controlled, ca. 9/arm	8	A: Soft, comm, veg B: Hard, comm, veg C: Hard, comm, veg D: Hard, comm, veg E: Hard, comm, veg F: Hard, comm, lard G: Hard, comm, veg H: Hard, comm, lard	17 32 25 28 22 17 34 24	45	-0.93 -0.58 -0.79 -0.67 -0.65 -1.10 -0.89 -0.56			
McOsker [21] 1962	22	X, controlled	56	A: Soft, comm, veg B: Hard, comm, veg C: Hard, expt, lard	11 16 6	39	-1.17 -0.94 -0.74			
de Jongh [22] 1965	33	linear, controlled	35	A: Hard, comm B: Hard, exp, fish C: Hard, exp, veg D: Hard, exp, fish E: Soft, exp, fish	16 16 39 28 5	30	-0.54 -0.59 -0.70 -0.72 -0.62			
Dalderup [23] 1969	577	X, free-living	91	Diet, comm, veg 4	24		-0.48			
Vessby [24] 1980	30	Linear, controlled	14	Diet, comm, veg 4	22		-0.90	-0.48	-0.05	
Kuusi [25] 1985	78	//, free-living	84	Diet, comm, veg 2	5		-0.26	-0.14	-0.06	
Judd [26] 1988	23	X, controlled	42	Soft, comm, veg 12	9		-0.39	-0.39	0	
Flynn [27] 1991	71	X, free-living	84	Hard, comm, veg 17	5		-0.23	-0.24	-0.02	

Table 1 (continued)

First author and year	N	Design and setting <sup>a</sup>	Days	Margarine	Amount (% calories ex- changed)	Difference in plasma cholesterol (margarine minus butter, mmol/l)		
						Total	LDL	HDL
				Type <sup>b</sup>	Trans content (g/100g)			
Fumeron [28] 1991 Nestle [29] 1992	36	X, free-living	21	Diet, comm, veg	4	-0.68	-0.48	-0.04
	27	Linear, free-living	21	A: Soft, expt, veg B: Soft, expt, veg C: Soft, expt, veg	5 21 0	-0.34 +0.03 -0.05	-0.31 +0.05 -0.05	0 0 +0.10
Seppanen [30] 1992 Wood [31] 1993	23	Linear, free-living	42	Soft, comm, veg	13	-0.08	-0.14	+0.01
	30	X, free-living	42	A: Hard, comm, veg	20	-0.18	-0.16	-0.03
Wood [32] 1993	40	X, free-living	42	B: Soft, expt, veg A: Hard, comm, veg	0 23	-0.05 -0.34	-0.11 -0.31	0 -0.05
	31	X, controlled	21	B: Diet, comm, veg	0	-0.62	-0.52	-0.05
Almendingen [3] 1995	31	X, controlled	21	A: Hard, expt, veg B: Hard, expt, fish	27 32	-0.21 +0.10	-0.23 +0.13	0 -0.07

<sup>a</sup> //, parallel design; X, cross-over design; Linear, sequential design, margarine fed after butter or vice versa.

<sup>b</sup> Comm, commercial brand; expt, experimental margarine; fish, containing partially hydrogenated fish or whale oil; lard, containing lard or beef tallow; veg, blend of (partially hydrogenated) vegetable oils.

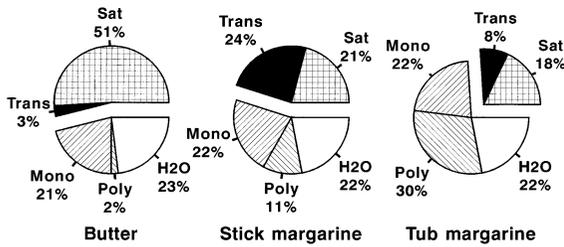


Fig. 1. Composition, in g per 100 g of product, of butter and of the average stick margarines ( $N = 32$ ) and tub margarines ( $N = 17$ ) used in the 20 experiments reviewed. Sat, saturated fatty acids; Trans, *trans* fatty acids; Mono, *cis*-monounsaturated fatty acids; Poly, polyunsaturated fatty acids; and H<sub>2</sub>O, water plus glycerol and other minor substances. Butter contains about 220 mg, vegetable margarines less than 1 mg, and margarines made with animal fats 70–275 mg cholesterol per 100 g of product.

product. The most abundant saturated fatty acid in both butter and margarine was palmitic acid (C16:0), followed in butter by myristic acid (C14:0) and followed by stearic acid (C18:0) in margarines. Hard stick or ‘brick’ margarines contained 16 g more *trans* and 19 g less polyunsaturated fatty acids per 100 g than the softer tub margarines (Fig. 1).

### 3.1. Effects on lipoprotein cholesterol

Substitution of margarine for butter lowered the total cholesterol level in 46 out of 49 comparisons (Fig. 2); for all margarines combined cholesterol decreased on average by 0.21 mmol/l ( $P < 0.001$ ; 95% CI,  $-0.23$  to  $-0.18$  mmol/l) per 10% of daily calories as margarine substituted for butter. Total cholesterol was lowered by 0.19 mmol/l (95% CI;  $-0.22$  to  $-0.16$  mmol/l) on stick and by 0.25 mmol/l (95% CI,  $-0.30$  to  $-0.20$  mmol/l) on tub margarine per 10% of calories exchanged ( $P = 0.05$  for difference between stick and tub

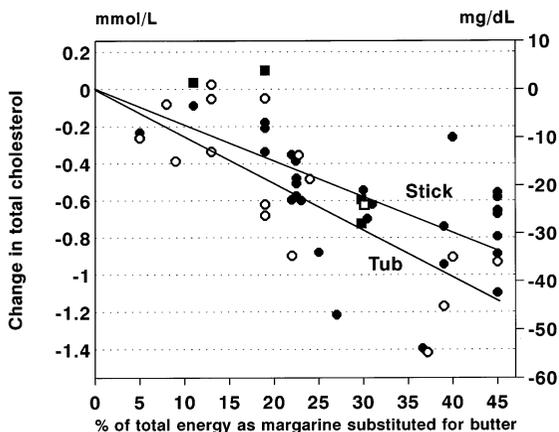


Fig. 2. Changes in total cholesterol levels on margarine versus butter diets in 20 studies providing 49 comparisons. (●) Hard stick vegetable margarine; (■) hard stick margarine with partially hydrogenated fish oil; and (○) soft tub margarine.

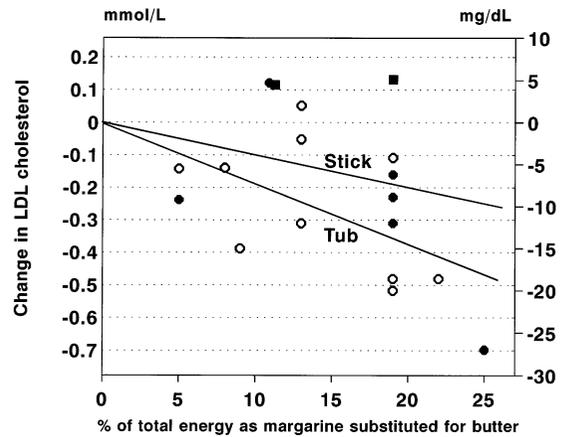


Fig. 3. Changes in LDL cholesterol levels on margarine versus butter diets in 20 studies providing 49 comparisons. (●) Hard stick vegetable margarine; (■) hard stick margarine with partially hydrogenated fish oil; and (○) soft tub margarine.

margarine). Excluding margarines containing partially hydrogenated fish oil did not change these results.

LDL cholesterol decreased by 0.15 mmol/l for all margarines combined ( $N = 18$ ;  $P < 0.001$ ; 95% CI,  $-0.22$  to  $-0.08$  mmol/l) (Fig. 3). It was lowered by 0.11 mmol/l per 10% of calories on stick ( $N = 8$ ;  $P = 0.066$ ; 95% CI,  $-0.24$  to  $+0.01$  mmol/l) and by 0.20 mmol/l on tub margarine ( $N = 10$ ;  $P < 0.001$ ; 95% CI,  $-0.28$  to  $-0.11$  mmol/l;  $P = 0.40$  for difference between stick and tub margarine). If margarines with hydrogenated fish oil were excluded, hard margarine lowered LDL cholesterol by 0.17 mmol/l ( $N = 6$ ;  $P = 0.021$ ; 95% CI,  $-0.29$  to  $-0.03$  mmol/l).

Fig. 4 shows the changes in HDL cholesterol and Fig. 5 those in the total/HDL cholesterol ratio. Stick margarine lowered HDL cholesterol by 0.02 mmol/l ( $N = 5$ ;  $P = 0.045$ ; 95% CI,  $-0.04$  to  $-0.00$  mmol/l) and non-significantly raised the total/HDL cholesterol

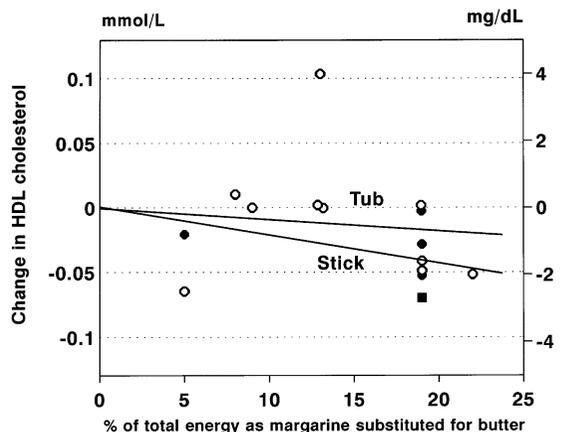


Fig. 4. Changes in HDL cholesterol levels on margarine versus butter diets in 20 studies providing 49 comparisons. (●) Hard stick vegetable margarine; (■) hard stick margarine with partially hydrogenated fish oil; (○) soft tub margarine.

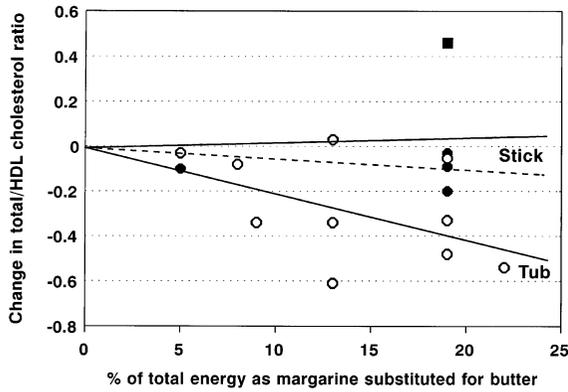


Fig. 5. Changes in the total to HDL cholesterol ratio on margarine versus butter diets in ten studies providing 15 dietary comparisons. (●) Hard stick vegetable margarine; (■) hard stick margarine with partially hydrogenated fish oil; (○) soft tub margarine. The dashed line represents the regression line for vegetable stick margarines.

ratio by 0.01 units ( $P = 0.83$ ) per 10% of calories relative to butter. Soft tub margarines did not significantly affect HDL cholesterol levels ( $-0.01$  mmol/l;  $N = 10$ ;  $P = 0.45$ ) and lowered the total/HDL cholesterol ratio by 0.20 units ( $P < 0.002$ ; 95% CI,  $-0.29$  to  $-0.10$ ,  $P < 0.025$  for difference with stick margarine). For stick margarines, these estimates were based on five comparisons involving 172 subjects. The one comparison using margarine with partially hydrogenated fish oil [3] showed a substantial increase in the total/HDL cholesterol ratio not observed for the other hard margarines. The vegetable stick margarines combined lowered the total/HDL cholesterol ratio non-significantly by 0.06 units per 10% of calories exchanged ( $N = 4$ ;  $P = 0.094$ ; 95% CI,  $-0.14$  to  $0.02$ ), which was still significantly smaller than the reduction of 0.20 seen with soft tub margarines.

Forty-six percent of the variance in the change in total cholesterol when margarine replaced butter was explained by the reduction in saturated fatty acids, whereas the change in *trans* fatty acid intake explained only 11%. In contrast, the change in the ratio of total to HDL cholesterol in plasma was significantly predicted only by the change in *trans* fatty acid intake (Fig. 6) ( $r^2 = 42\%$ ,  $P = 0.009$ ), but not by the change in saturated fatty acid intake ( $r^2 = 2\%$ ,  $P = 0.62$ ).

### 3.2. Other cardiovascular risk factors

Effects on serum triglycerides were minimal. Changes in apolipoprotein A-I and B generally followed changes in HDL and LDL cholesterol [3,24,28,31,32]. Margarines raised lipoprotein(a) levels in two studies [3,29] compared with butter. A high-linoleic acid, low-*trans* margarine was reported to prolong blood clotting time [34].

## 4. Discussion

### 4.1. Lipoprotein cholesterol

Replacement of butter by margarine reduced the total and LDL cholesterol concentration, but hard stick margarines also produced somewhat lower HDL cholesterol levels. As a result the total to HDL cholesterol ratio was not significantly changed. Soft tub margarines did significantly reduce the total to HDL cholesterol ratio. This ratio is probably the best blood lipid predictor of coronary heart disease [35], and high values are associated with markedly increased risk [36]. Our data thus suggest that improvement of the lipoprotein risk profile through replacement of butter by margarine is feasible but that it depends on the type, and consequently the fatty acid composition, of the margarine.

### 4.2. Fatty acid composition of margarines

Some margarines are an important source of dietary *trans* fatty acids, while butter is high in saturated fatty acids but contains only a low proportion of *trans*. *Trans* fatty acids and saturates produce similarly high levels of LDL cholesterol in plasma, but *trans* fatty acids also lower HDL cholesterol [37]. One might therefore expect that substitution of margarines for butter would increase the ratio of total to HDL cholesterol in plasma, or at best leave it unchanged. However, we found that soft margarines decreased the ratio of total to HDL cholesterol as compared with butter, whereas hard margarines did not. The explanation of these findings probably lies in the absolute amounts of *trans* and saturated fatty acids in butter in comparison with margarines. As illustrated in Fig. 1, the combined amount of saturated plus *trans* fatty acids in the studies reviewed was about 54/100 g for butter, 45/100 g for hard stick margarines and about 26/100 g for softer tub margarines, the remainder being *cis*-unsaturated fatty acids. Analysis of food fats sold nowadays in the US and Europe [38,39] also shows that the saturated plus *trans* fatty acid content is commonly highest in butter, intermediate in stick, and lowest in tub margarines. Replacement of butter by margarine thus involves replacing saturated fat by a mix of *trans* and *cis* unsaturated fat. If the proportion of *trans* is high, as it is in stick margarines, the effect on the total to HDL cholesterol ratio in plasma will be nil. If butter is replaced by a margarine low in *trans* and high in *cis*-unsaturated fat the total/HDL cholesterol ratio in plasma will fall [40]. Hard margarines with partially hydrogenated fish oil may contain higher amounts of saturated plus *trans* fatty acids than butter; the study by Almendingen et al. [3] shows that such margarines may increase the total/HDL cholesterol ratio compared with butter and with

hard margarines containing partially hydrogenated vegetable oils (Fig. 5).

European soft margarines nowadays contain less *trans* than the products reviewed here (Fig. 1) or sold in the US [39,41]. Such soft margarines are low in saturated and free of *trans* fatty acids, and are thus expected to produce somewhat lower total/HDL ratios than the soft margarines reviewed here.

Until recently, stick margarines in both Europe and the US contained 15–25 g *trans* per 100 g product [39,42]. Outside the US, hard margarines are increasingly made with tropical oils instead of partially hydrogenated oils, both because of price and because of the negative publicity about *trans* fatty acids. This confers a health benefit if the sum of *trans* plus saturated fatty acids in the product is lowered, but not if a decrease in *trans* fatty acids is bought at the expense of a larger increase in lauric, myristic, or palmitic acid, which will raise LDL cholesterol [43]. For optimal effects on the lipoprotein profile, the sum of *trans* plus saturated fat in margarines should be as low as possible.

Replacement of butter by vegetable margarines also reduces cholesterol intake, and this accounts for about 30% of the fall in total cholesterol observed here (Fig. 2) [44,45]. However, the reduction in dietary cholesterol also lowers HDL cholesterol [46–49]; therefore the observed changes in the total to HDL cholesterol ratio are probably due to changes in fatty acid rather than cholesterol intake.

#### 4.3. Methodological issues

The number of subjects varied widely between studies. However, weighting each comparison by the square root of the number of subjects yielded results virtually identical to those obtained by unweighted regression. Stratification of the dietary comparisons according to study design (cross-over, parallel, or sequential) or according to study setting (metabolic ward versus free-living) also did not affect outcomes. However, the effects of study setting could not be separated from the effect of the type of margarine used (Table 1); soft margarines were predominantly tested in free-living settings, where the amount of margarine consumed may have been less than prescribed. The effects of soft margarines could thus have been underestimated. Excluding one study [20] which provided 16 comparisons for total cholesterol did not affect outcomes. Thus, our findings changed little when different analytical approaches were used.

#### 4.4. Labelling of food fats

Our data suggest that knowledge of the saturated fat content of dietary fats is not sufficient to predict their effect on coronary heart disease risk. Changes in satu-

rated fat intake predicted 46% of the variance of the change in total cholesterol but none of that in the total to HDL cholesterol ratio, which is a better predictor of coronary heart disease than the level of total cholesterol [36]. In contrast, the change in *trans* fat predicted 42% of the change in the total/HDL cholesterol ratio. Fig. 6 illustrates that the total/HDL cholesterol ratio was favourably affected in those experiments in which margarine supplied about the same amount of *trans* fatty acids as butter (zero change), and was less affected or increased with margarines supplying larger amounts of *trans* fat. This is consistent with the unfavourable effect of *trans* fatty acids on the total/HDL cholesterol ratio observed in recent trials [50]. Food labelling regulations in most countries require declaration of the saturated fat content but not of the *trans* content. Nearly half of the margarines sold nowadays in the US are of the more traditional stick type, which contain substantial amounts of *trans* fatty acids [51]. Adding the *trans* contents on labels would help patients with moderate hypercholesterolemia to select foods that lower their total to HDL cholesterol ratio in blood.

#### 4.5. Predicted consequences for CHD risk

Each 0.6 mmol/l decrease in total or LDL cholesterol reduces coronary heart disease risk by 50% at age 40 [52]. Based on these figures, substituting 10% of calories or 30 g of margarine for butter (25 g of triglycerides) in a 2200 kcal diet would reduce CHD risk by 9–16% for stick and by 17–21% for tub margarine. However, such an approach ignores changes in HDL cholesterol induced by margarines. There is evidence that HDL is causally involved in atherosclerosis [53–57] and thus a more prudent approach should take changes in plasma HDL into account. We therefore based calculations of heart disease risk on the ratio of total to HDL choles-

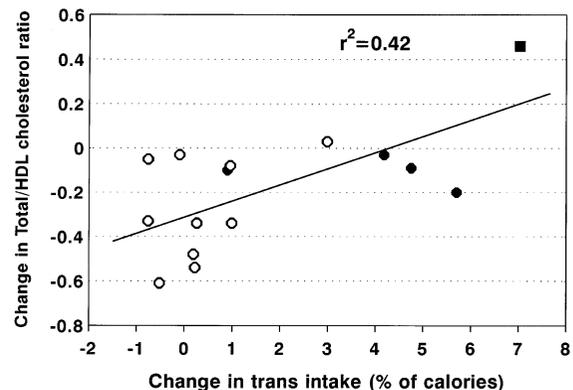


Fig. 6. Changes in the ratio of total to HDL cholesterol in 15 dietary comparisons as a function of the change in *trans* fatty acid intake accompanying the replacement of butter with margarine. (●) Hard stick vegetable margarine; (■) hard stick margarine with partially hydrogenated fish oil; (○) soft tub margarine.

terol, which is a superior measure compared with either total or LDL cholesterol [36].

Our estimate of the effect of hard stick margarine on total/HDL cholesterol was based on five data points (Fig. 5), but these comprised a total of 172 subjects studied in properly controlled trials in three locations over periods of 3–12 weeks. Elimination of the one outlying comparison did not materially affect the estimate. We therefore regard our estimate as the best figure currently available for the effect of hard stick margarine on the total/HDL cholesterol ratio. Every reduction of 0.01 in this ratio reduces the risk of myocardial infarction by approximately 0.5% [35]. This would imply that replacing 30 g of butter with stick margarine would not affect CHD risk, while replacing butter with soft tub margarine would reduce the risk by 10%. A still larger risk reduction might be achieved by replacing butter and other hard fats with modern low-saturated zero-*trans* margarines, which have a fatty acid composition approximating that of liquid oils [58].

Our risk predictions agree with the outcomes of the Finnish Mental Hospital Study [59,60], in which replacement of butter and dairy fats by a soft margarine low in *trans* and high in *cis*-polyunsaturated fatty acids lowered CHD incidence by 45% in the men ( $P = 0.008$ ) and by 36% in the women ( $P = 0.07$ ) during 6 years of treatment. As for other risk factors, *trans* fatty acids raise lipoprotein(a) levels [3,29,61]; this might cause some additional increase in CHD risk when large amounts of hard *trans*-rich margarines are consumed. Blood pressure is probably not affected by exchanging butter and margarine [62–65]. The effects of different fatty acids on blood clotting tendency and fibrinolysis are poorly understood, but some studies tend to favour *cis*-unsaturated over saturated fatty acids [34,66,67]. Cholesterol in butter probably does not affect the total to HDL cholesterol ratio, but it has been argued that dietary cholesterol is atherogenic-independent of its effect on lipoprotein cholesterol [68]. This would imply that reducing cholesterol intake by substituting margarine for butter would add to the CHD risk reduction caused by changes in fatty acid intake.

In US Nurses, consumption of margarines and of *trans* fatty acids from vegetable fats was associated with a significant increase in CHD risk [5]. In Framingham, consumption of margarine—but not butter—at entry was associated with CHD incidence in men in the next 20 years [69]. The Nurses recorded their diets in 1980 and the Framingham men in 1966–69, and it is likely that the margarines and shortenings consumed in the US at that time were mainly hard, high-*trans* products [70]. In the Iowa Women's Health Study, consumption of margarine was negatively associated with CHD mortality [71]. This association weakened after adjustment for vitamin E intake, suggesting that it could be partly attributed to protection by vitamin E. However, vita-

min-E-rich margarines are generally also rich in polyunsaturated fatty acids, and they also tend to be lower in *trans* [42]. Thus, vitamin E content may be a marker for the type of margarine, and the data from the Iowa women [71] are compatible with a protective effect of soft tub margarines.

## 5. Conclusion

Our findings support recent FAO/WHO recommendations that consumers should replace hard fats with liquid oils and soft fats to reduce the intake of both saturated and *trans* fatty acids [72]. However, consumers can make optimal choices only if *trans* contents are reported on the labels of food fats.

## Acknowledgements

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