Association of serum lipids with coffee, tea, and egg consumption in free-living subjects

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SUMMARY The associations of serum lipids with coffee, tea, and egg consumption were examined in a survey of 658 men in Israel. A significant, positive association was found between coffee consumption and serum total cholesterol (TC), mainly reflecting a difference in the low density lipoprotein cholesterol (LDL-C). Among the subjects aged 20–39, the difference in TC between the lowest and highest consumption categories was 13.2 mg/dl, and among those aged 40–69 the difference was 7.4 mg/dl. An even stronger, negative association between tea intake and TC was present; the difference between the lowest and highest consumption categories was 28.7 mg/dl for the younger subjects and 18.4 mg/dl for the older group. On the other hand, serum TC levels were not elevated at higher levels of whole egg consumption. Thus, allowing for the bias inherent in dietary recall, coffee and tea consumption appear to be associated more strongly with serum lipid and lipoprotein levels than egg consumption.

Since a number of dietary factors appear to affect serum lipids, public health measures directed at reducing levels of serum cholesterol are likely to be most effective if they are relatively easy to implement. Current recommendations regarding prudent diets in American populations include reducing the daily cholesterol consumption to less than 300 mg per day.¹ It has been pointed out that in order to meet these recommendations, the intake of eggs would have to be reduced far below current consumption levels.² This restriction may be particularly severe in view of the relatively low cost and high nutritional value of eggs. In addition, despite evidence from laboratory studies which show a positive association between egg consumption and serum cholesterol levels,^{3–5} some investigators have found that moderate egg intake does not affect cholesterol levels.^{6–8}

Tea and coffee are two other commonly consumed items of diet that have been suggested as affecting blood lipids. A number of researchers have reported a strong, positive association between serum lipid levels and the consumption of coffee.^{9–11} On the other hand, tea consumption does not appear to be associated with serum lipids in the same way as coffee.^{12–14} The present epidemiological study was designed to examine the associations of coffee, tea, and egg consumption with serum lipids and lipoproteins in a group of clinically healthy, occupationally active men. The food items

selected for the study were chosen because they are consumed by a large percentage of the population, and modification of their consumption could be a convenient method of intervention in lipid-lowering programmes.

Methods

STUDY POPULATION

Between 1983 and 1984, male employees of six factories in Israel, involved in either sedentary or physical work, were screened for risk factors for cardiovascular disease. Every employee was offered the examination free of charge. The response rate was 84.5%, and data were obtained on 830 individuals.

EXAMINATION

Information collected on each subject included detailed demographic data, personal habits including smoking, frequency of participation in leisure-time physical activity, a detailed history of daily coffee, tea, and alcohol drinking, and weekly egg consumption. In addition, subjects were questioned about medication taken and whether they followed special diets (such as low salt, low cholesterol, low saturated fat or weight reducing diets). Height and weight were measured. Relative weight was defined by the Quetelet index = (weight in g)/(height in cm²).

BLOOD TESTS

Venous blood samples were drawn in vacuum tubes without additive, with the subjects supine and after fasting for between nine and ten hours. Serum was separated from the whole blood within two hours of being drawn. Sera were maintained frozen at -70°C before being analysed. Analyses were carried out on an Abbott VP autoanalyser. Total cholesterol (TC) was determined by the enzymatic colour method (Lancer). HDL cholesterol (HDL-C) was measured after precipitation with magnesium phosphotungstate (Sigma). Triglycerides were determined by the enzymatic colour method (Biotrol). Serum low density lipoprotein cholesterol (LDL-C) was estimated from the following formula¹⁵:

$\text{LDL-C} = \text{TC} - \text{HDL-C} - (\text{Triglycerides}/5)$. Quality control methods were employed throughout all the analyses.

EXCLUSIONS

Any subject who reported adhering to any special diet was excluded from the analyses in order to avoid bias resulting from artificial dietary manipulations which may affect blood lipid levels. In addition, subjects on antihypertensive drug therapy were excluded due to the possible effects of the drugs on serum lipids. These conditions excluded 20.7% of the subjects; therefore a total of 658 subjects were included in the analyses.

STATISTICAL METHODS

The chi-square statistic was used to test for associations between consumption of the dietary

variables. Analysis of covariance was used to examine the association between the dietary factors and the lipid levels. Since the preliminary analyses suggested various interaction effects with age, and in order to simplify the interpretation of the interactions, separate analyses of covariance were carried out in each of two age groups, 20–39 and 40–69 years. The term “statistically significant” in the text implies a significance level of 5%.

Results

POPULATION CHARACTERISTICS

The characteristics of the population studied are given in table 1. Coffee, tea, and egg consumption by age group is shown in table 2. Heavy coffee drinking (> 5 cups/day) was reported by 12.0% of the younger group and 6.9% of the older group. Heavy tea drinking (> 5 cups/day) was reported by 6.1% of the younger group and 6.6% of the older group. Consumption of ten or more eggs per week was reported by 9.4% of the younger group and 6.0% of the older group. A strong negative association between coffee and tea drinking ($p < 0.001$) was found in both groups. Smoking showed a strong positive association with coffee drinking in both groups ($p < 0.001$ in the younger and $p = 0.01$ in the older group), but not with tea drinking. No significant association was found between egg consumption and coffee or tea drinking.

ANALYSIS OF COVARIANCE

The adjusted means by nutrient consumption categories are presented in tables 3 to 5. In each case the dependent variable was adjusted for age, Quetelet, smoking status (non-smoker, less than or more than 20 cigarettes per day), alcohol consumption (more or less than three times per week), and participation in leisure time sport (more or less than twice a week). Sugar added to coffee or tea was introduced into the analyses as a potential confounder but had no effect and is not included in the analyses presented in the tables.

COFFEE CONSUMPTION

Among the younger group, TC was found to be significantly positively associated with coffee intake

Table 1 Characteristics of the study population, men aged 20–69 years (means + standard deviation)

	Age (years)	
	20–39	40–69
n	309	349
Quetelet	2.45 + 0.31	2.64 + 0.37
% Smokers	36.9	32.2
TC (mg/100 ml)	187.7 + 40.2	212.3 + 42.5
HDL-C (mg/100 ml)	46.6 + 13.2	47.4 + 14.7
LDL-C* (mg/100 ml)	112.6 + 37.2	133.0 + 40.7
TRIG (mg/100 ml)	142.7 + 84.3	159.6 + 88.1

TC = total cholesterol; HDL-C = high density lipoprotein cholesterol; TRIG = triglycerides; LDL-C* = $\text{TC} - \text{TRIG}/5 - \text{HDL-C}$.

Table 2 Percentage distribution of coffee, tea, and egg consumption by age group

Age (years)	N	Cups of coffee/day				Cups of tea/day				Eggs/week			
		0	1–2	3–4	5+	0	1–2	3–4	5+	0–3	4–6	7–9	10+
20–39	309	12.9	41.4	33.7	12.0	25.9	48.9	19.1	6.1	32.4	45.6	12.6	9.4
40–69	349	15.8	53.9	23.5	6.9	20.1	53.3	20.1	6.6	45.0	39.3	9.7	6.0

(table 3). There was essentially no difference in the lipid levels between the categories 0 cups/day and 1–2 cups/day, and between the categories 3–4 and 5+ cups/day. The difference in TC between the highest and lowest categories was 13.2 mg/dl. Much of this difference (8.8 mg/dl) was accounted for by the cholesterol in the LDL fraction. No significant differences were noted in HDL-C and triglycerides, although those who consumed the most coffee had triglyceride concentrations 15.3 mg/dl greater than those who did not drink coffee at all. In the older group, the differences between the highest and lowest coffee consumers in total and LDL-C were still present (7.4 mg/dl for TC and 16.4 mg/dl for LDL-C) although in contrast to the younger group the difference in TC was less whereas that in the LDL fraction was greater and statistically significant. In the range of consumption examined there was no evidence of a linear trend, and the data were suggestive of a threshold-type effect above 2 cups/day. Although in the older group statistically significant differences in the HDL fraction were present, they did not parallel coffee drinking.

TEA CONSUMPTION

In the younger group there was a strong negative association between tea consumption and TC (a difference of 28.7 mg/dl, table 4) and this was due entirely to the difference in LDL-C (33.1 mg/dl). Triglycerides were significantly higher (31.3 mg/dl) in the group consuming the most tea. There was no consistent trend with HDL-C. The negative association between tea consumption and TC was less marked in the older group (a difference of 17.4 mg/dl

Table 3 *Adjusted* mean levels of serum cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides according to coffee consumption*

		<i>Lipids and lipoproteins (mg/100ml)</i>			
<i>Cups/day</i>	<i>n</i>	<i>TC</i>	<i>HDL-C</i>	<i>LDL-C</i>	<i>TRIG</i>
<i>Men aged 20–39 years</i>					
0	40	186.6	47.7	109.3	147.6
1–2	128	180.9	46.3	107.6	134.8
3–4	104	192.2	45.4	118.1	143.4
5+	37	199.8	49.2	118.1	162.9
p		0.0287	0.4269	0.1213	0.2824
<i>Men aged 40–69 years</i>					
0	55	209.8	46.9	126.1	183.4
1–2	188	210.2	49.3	129.2	158.3
3–4	82	217.4	43.7	143.4	151.8
5+	24	217.2	46.2	142.5	142.7
p		0.5642	0.0373	0.0261	0.1039

* Adjusted for age, Quetelet, smoking status, alcohol consumption, and participation in leisure-time sport.

Abbreviations: see Table 1.

Table 4 *Adjusted* mean levels of serum cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides according to tea consumption*

		<i>Lipids and lipoproteins (mg/100ml)</i>			
<i>Cups/day</i>	<i>n</i>	<i>TC</i>	<i>HDL-C</i>	<i>LDL-C</i>	<i>TRIG</i>
<i>Men aged 20–39 years</i>					
0	80	199.8	45.3	123.5	155.3
1–2	151	185.4	48.2	110.9	131.4
3–4	59	182.6	45.1	109.5	140.4
5+	19	171.1	43.4	90.4	186.6
p		0.0042	0.1778	0.0015	0.0097
<i>Men aged 40–69 years</i>					
0	70	223.9	47.3	144.0	162.8
1–2	186	211.4	48.5	131.4	157.5
3–4	70	205.1	45.0	129.0	155.8
5+	23	206.5	46.1	124.6	178.7
p		0.0572	0.3852	0.0767	0.6695

* Adjusted for age, Quetelet, smoking status, alcohol consumption and participation in leisure-time sport.

between the highest and lowest consumers), again entirely due to the difference in the LDL fraction (19.4 mg/dl). There was no significant association with HDL-C or with triglycerides, although those consuming the most tea had triglycerides 15.9 mg/dl greater than those not drinking tea at all.

COFFEE AND TEA AS CONFOUNDERS FOR ONE ANOTHER

Separate analyses were carried out introducing coffee as the effect variable and tea as a covariate, and *vice versa*. When tea was introduced as a covariate, there was no longer any significant association between coffee drinking and TC in both age groups ($p=0.07$ for the younger group and $p=0.78$ for the older group). However, when tea drinking was included as the effect variable and coffee as the covariate, the significant negative associations found between tea drinking and the lipids persisted in the younger group, with a difference in TC between the highest and lowest consumption categories of 26.6 mg/dl. The comparable difference in TC for the older group was 16.4 mg/dl, but this did not achieve statistical significance.

EGG CONSUMPTION

The results for egg consumption are presented in table 5. In the younger group no significant association was observed between egg consumption and serum lipid levels (a difference of 2.6 mg/dl in TC and 5.8 mg/dl in LDL-C). However, in the older group there was a negative association between egg consumption and TC (a difference of 16.6 mg/dl between the highest and lowest consumption categories), due to the difference in the cholesterol in the LDL fraction (19.4 mg/dl).

Table 5 Adjusted* mean levels of serum cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides according to egg consumption

		<i>Lipids and lipoproteins (mg/100ml)</i>			
<i>Eggs/day</i>	<i>n</i>	<i>TC</i>	<i>HDL-C</i>	<i>LDL-C</i>	<i>TRIG</i>
<i>Men aged 20-39 years</i>					
0-3	100	189.0	46.8	112.7	147.6
4-6	141	186.5	46.5	112.1	139.4
7-9	39	186.2	46.3	110.1	149.1
10+	29	191.6	46.5	118.5	133.0
p		0.8886	0.9969	0.7969	0.7164
<i>Men aged 40-69 years</i>					
0-3	157	217.0	47.8	137.6	157.7
4-6	137	212.3	47.7	133.4	155.8
7-9	34	198.0	42.4	118.9	182.2
10+	21	200.4	50.2	118.2	160.5
p		0.0616	0.1765	0.0313	0.3750

* Adjusted for age, Quetelet, smoking status, alcohol consumption, and participation in leisure time sport.

Discussion

In the present study, serum TC and LDL-C levels were positively associated with coffee consumption and negatively associated with tea consumption. The negative association of serum lipids with tea drinking was more striking than the positive association observed with coffee consumption, in contrast to the findings of other studies.^{13 14} The association between whole egg consumption and serum lipid levels was either absent or negative. Results of the present study are compared with those of other reported studies.

COFFEE CONSUMPTION AND SERUM LIPIDS

In a review of the literature, Mathias *et al*¹⁶ found that a significant positive association between coffee drinking and serum cholesterol has been demonstrated in most but not all epidemiological studies. Some authors describe a significant association in men only¹⁷ while others found it only in women.^{16 18 19} Others have noted the association in selected subgroups such as myocardial infarction survivors,¹² smokers,⁹ and vegetarians.¹⁰ In controlled trials, coffee drinking produced an elevation of serum cholesterol,²⁰ while abstinence from coffee tended to produce a decline in serum lipids in hypercholesterolaemic men.²¹ The release of free fatty acids induced by coffee drinking has been suggested as one of the mechanisms producing the association between coffee and cholesterol.²²

In the present study, the associations between coffee consumption and TC and LDL-C were quite strong. A threshold effect at 3 cups/day was observed mainly in the younger group. It should be noted that these associations were found at relatively low levels of

coffee drinking. No information was available as to whether milk was added to the instant coffee. The possible contribution of milk or cream added to the coffee has been examined in other studies and not found to be significant. In the present study about two thirds of the subjects reported drinking black ground coffee, and the rest instant coffee. In Israel, cream is not generally added to instant coffee, and the results were essentially unchanged when consumption of ground coffee and instant coffee were analysed separately.

Tea drinking appeared to be a strong confounder of the association between coffee drinking and serum lipids. In the earlier studies on coffee drinking and serum lipids, adjustment for tea drinking as a possible confounding variable was not reported. This may have been due either to the fact that tea consumption was not found to be significantly associated with serum lipids¹⁴ or to the lack of information on tea drinking habits.¹⁶ In one study in which coffee drinking was positively associated and tea drinking negatively associated, with serum lipids,¹² the two dietary factors were not evaluated as potential confounders of their respective associations with the lipids. Another factor not explicitly taken into account in most of the earlier studies was the interaction of age with coffee consumption in its association with serum lipid levels. The serum lipid/coffee drinking association appears to diminish with increasing age. These potential confounding and interacting factors may explain some of the inconsistencies in the findings from the reported studies.

Despite the positive association of coffee with serum cholesterol levels, the results of the studies on the association between coffee intake and acute myocardial infarction have been inconclusive. Hennekens *et al*²³ demonstrated a weak association which disappeared after controlling for cigarette smoking, whereas others found no association.²⁴

TEA CONSUMPTION AND SERUM LIPIDS

The strong negative association that we observed between tea drinking and TC and LDL-C is striking. When coffee drinking was introduced into the analyses as a potential confounding variable the negative association between tea drinking and serum cholesterol was diminished, although not eliminated. Thus, while the inverse tea-cholesterol association may be partly due to lower coffee intake among tea drinkers, tea drinking does appear to have an independent association with serum cholesterol levels. The few reported studies on the association between tea drinking and serum cholesterol have not yielded consistent findings. Little¹² found a negative association between tea drinking and serum lipids, whereas Haffner *et al*¹⁴ did not observe any significant

association. In a laboratory study, Akinyanju and Yudkin²⁵ found that rats experienced a rise in cholesterol when fed coffee and a decline in cholesterol after being fed tea. Caffeine in tea was examined in an epidemiological study¹³ and found to be associated with increased cholesterol in females. The role of caffeine *per se* was not examined in the present study, as no information was available on the use of decaffeinated coffee or tea. At the time of this study, decaffeinated beverages were rarely consumed in Israel.

EGG CONSUMPTION AND SERUM LIPIDS

The association of the consumption of cholesterol-rich foods, such as eggs, with serum cholesterol has long been a controversial subject. Metabolic ward experiments have demonstrated a positive effect of egg intake on serum cholesterol. Various investigators have found that egg feeding causes an increase in cholesterol levels.^{5,26} However, in a study of free-living subjects, Dawber *et al*²⁷ found no relation between egg consumption and cholesterol levels or CHD incidence. In a smaller group of vegetarians, Sacks²⁸ demonstrated an increase in serum cholesterol with increased egg intake.

In the present study, at the levels of egg consumption examined, no association was observed between egg consumption and serum cholesterol in the younger group. Among the older subjects there was even evidence of a negative association between egg consumption and cholesterol. This phenomenon may be due to the use of eggs as an alternative to other foods with high cholesterol and saturated fat content (eg, meat products), which have a stronger effect on serum cholesterol. Thus, while eggs added to the diet may have a hypercholesterolaemic effect, their role in determining serum lipid levels when consumed as part of a regular diet may be limited.

POTENTIAL SOURCES OF BIAS

The use of questionnaires based on frequency of food intake may introduce a bias. In the present study, information was available only on whole egg consumption. Clearly, eggs are presented in various quantities in other prepared foods. If those consuming more whole eggs restrict the quantity of egg included in prepared food, this would tend to diminish any possible positive association between egg intake and serum cholesterol. Since all persons observing special diets were excluded from the analyses, there is no reason to suspect that such a phenomenon occurred.

Conclusion

The detection of associations between serum lipids and dietary factors determined from self-reported

dietary histories is always problematical. This fact has been one of the grounds for criticism of epidemiological studies that have failed to detect an association between the levels of dietary cholesterol and serum lipid levels. However, in the present epidemiological study, while serum cholesterol was not elevated at higher levels of egg consumption, it was significantly, positively associated with coffee drinking and negatively associated with tea drinking. These findings are from the same study population and based on the same questionnaire technique for determining intake of each of the dietary factors. Thus it appears that coffee and tea drinking are stronger correlates of serum lipids than whole egg consumption; replacement of coffee by tea may provide a more convenient means of intervention for the lowering of blood lipids than restriction of egg intake. Clearly, these results relate to the ranges of nutrient consumption as observed in this population, and it may not be possible to generalise them to females.

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