EFFECT OF HEAVY CIGARETTE SMOKING ON POSTPRANDIAL TRIGLYCERIDES, FREE FATTY ACIDS, AND CHOLESTEROL*

BY

AARNE KONTTINEN, M.D.

AND

MATTI RAJASALMI, B.Sc.

Wihuri Research Institute, Helsinki

The many-sided problem of atherosclerosis has stimulated investigation into the relationship between serum lipid levels and cigarette smoking. In several population studies the serum cholesterol has been observed to be higher in smokers than in non-smokers (Gofman, Lindgren, Strisower, deLalla, Glazier, and Tamplin, 1955; Thomas, 1958, 1960; Miller, Trulson, McCann, White, and Stare, 1958; Karvonen, Orma, Keys, Fidanza, and Brozek, 1959; Dawber, Kannel, Revotskie, Stokes, Kagan, and Gordon, 1959; Blackburn, Brozek, Taylor, and Keys, 1960; Bronte-Stewart, 1961) with the exception of two studies on old men (Acheson and Jessop, 1961) and young men (Konttinen, 1962). The biological evidence of the effect of cigarette smoking on fat metabolism in such studies is, however, only a pointer, and the causal relationship of smoking to fat metabolism is obscure, while that to atherosclerosis is still conjecture only.

It is a difficult task to take into account the multitude of factors that can be included in a comparison between smokers and non-smokers in studying serum lipid levels. It is possible to eliminate the effect of the subject's bodyweight, but possible differences in, for example, food consumption brought about by smoking habits are more complicated to rule out. There is evidence that the taste perception of smokers may differ from that of non-smokers (Thomas and Cohen, 1960; Krut, Perrin, and Bronte-Stewart, 1961) and this may lead to differences in the selection of foods and thus also to differences in serum lipid levels. It is also worth mentioning that there may be constitutional differences (Lawton and Phillips, 1956; Heath, 1958; Friberg, Kaij, Dencker, and Jonsson, 1959) which express themselves in serum-lipid levels and smoking habits without the two factors standing in any causal relationship to each other.

A rather limited number of studies have been made, however, to elucidate the effect of cigarette smoking on fat metabolism. In studies concerning the effect on serum cholesterol of the smoking of a few cigarettes, the results point to doubtful or no elevations (Strauss and Scheer, 1936; Short and Johnson, 1939; Högler, 1943; Page, Lewis, and Moinuddin, 1959). In a recent study Kershbaum, Bellet, Dickstein, and Feinberg (1961) observed that smoking has an increasing effect on plasma-free fatty acids. As smoking cigarettes just after a meal is a very common habit, the present study was undertaken to investigate the post-prandial level of serum triglycerides, plasma-free fatty acids, and serum cholesterol in relation to cigarette smoking.

Material and Methods

The subjects were 40 healthy soldiers aged 19 to 20 years. They were habitual smokers of American-type filter-tip cigarettes and were accustomed to smoking 15 to 20 or more cigarettes a day. All had been smokers for at least two years.

Just before the experiment the men were divided at random into two groups—those who were to smoke and those who were not to smoke during the experiment. This was to last for six hours. Those who smoked started to do so immediately after a fat meal.

This was given at 7.30 a.m. and consisted of 100 ml. of 40% cream and a pat of butter (15 g.), the total amount of ingested fat being 55 g. With this the men were given a piece of bread weighing 50 g., 15 g. of sugar, and 400 ml. of tea. On the day before the experiment they had had dinner at 5 p.m. and coffee with a piece of cake at 7 p.m. Only clear water was allowed thereafter. Thus the men had fasted for 12 hours before the beginning of the experiment. They were allowed to smoke on the previous evening, but not in the morning before the experiment.

Two observers were present throughout the six hours to ensure that the experiment really took place as described. Except for smoking, the men in the two groups behaved in exactly the same way. They were in the same room and could move and sit freely, though they were not allowed to lie down. Exercise of any kind, which has been observed to have an effect on triglycerides and free fatty acids (Nikkilä and Konttinen, 1962), was prohibited.

The smokers were asked to smoke as heavily as possible by inhaling American-type filter-tip cigarettes containing 0.9 g. of Virginia- and Turkey-blend tobacco with a nicotine content of 20 mg. The number of cigarettes smoked was counted at two-hourly intervals. The average number smoked during the six hours was 22.8 cigarettes (range 19 to 27). During the first two hours the number smoked averaged 6.7 cigarettes (range 5 to 8).

During the experiment four blood samples were taken from the cubital vein with minimal stasis. The first was taken just before the meal and the others at intervals of two hours after the meal, the fourth specimen being taken six hours after the meal. The samples were taken from both groups of men at the same time. To avoid lengthening of the intervals the trial was carried out on three different days, each day with the same number of men from both groups. The serum and plasma were centrifuged immediately after sampling, and the samples were kept in the refrigerator at −20° C. until analysed within a week, in pairs from each group of men. Triglycerides (Van Handel and Zilversmit, 1957) and cholesterol (Anderson and Keys, 1956) were determined in serum, and free fatty acids (Trout, Estes, and Friedberg, 1960) in plasma. All lipid measurements were carried out in duplicate.

Results

The Table gives the mean values with standard errors of the mean for the lipids studied in the course of the experiment. There was a prompt rise in the serum triglycerides in the non-smoking group two hours after the fat meal, whereas the rise in the smoking group was only slight. The difference between the groups is probably significant ($P<0.05$). Four hours post-prandially the triglyceridaemia reached a significantly ($P<0.01$) higher level in the non-smoking group than in the smoking group, and at six hours a decrease to an equal level had occurred in both groups. An increase in plasma-free fatty acids took place during the whole period of investigation toward the six hours' value, the increase being highly significant ($P<0.001$) at this time both in the smoking and the non-smoking groups. There was a slightly greater numerical increase in the smoking group, which, however, was statistically insignificant. In serum cholesterol no differences were seen between the groups during the smoking period.

*Aided by Amer-Tupakka oy, Hyrylä, Finland.

Mean Values and Standard Errors of the Mean for Serum Lipids in Men Smoking and Not Smoking During Experiment

Lipid	Subjects	No.	Before Meal	Time after Meal (hr.)		
				2	4	6
Triglycerides, mg./100 ml.	Smoking	20	86·4±7·56	117·2±9·52	120·6±10·00	102·8±10·84
	Non-smoking	20	88·1±6·52	144·7±8·03	157·9±12·41	109·7±11·21
Free fatty acids, μEq./l.	Smoking	20	426·8±31·1	555·2±33·4	790·6±44·9	882·4±45·7
	Non-smoking	20	425·0±23·4	560·9±31·3	722·0±36·8	816·7±38·6
Total cholesterol, mg./100 ml.	Smoking	20	188·9±10·2	182·6±9·38	189·9±8·87	205·6±13·6
	Non-smoking	20	181·6±8·81	183·5±10·4	186·8±8·44	192·3±7·72

Discussion

The smaller elevation of post-prandial triglyceridaemia in the smoking than in the non-smoking group was clearest four hours after the meal when the level of serum triglycerides was 120.6 mg./100 ml. in the smoking and 157.9 mg./100 ml. in the non-smoking group. In previous investigations there has been no evidence of the effect of smoking on post-prandial triglyceridaemia (Larson, Haag, and Silvette, 1961a ; 1961b). Rises in the serum chylomicron have been observed in some individuals studied during smoking (Becker, Meyer, and Necheles, 1950 ; Marder, Becker, Maizel, and Necheles, 1952). In the fasting state, however, Kershbaum *et al.* (1961) did not find that the smoking of two cigarettes affected the serum triglycerides. In the present study smoking was quite heavy, an average of 23 cigarettes being smoked by each man during the whole six-hour period. The total amount of nicotine inhaled can thus be held to represent approximately 55 to 70 mg. (Roth, 1960). In the course of the first two hours, when a difference had already occurred between the groups, the men smoked on the average seven cigarettes.

It seems probable that the explanation for the decreased post-prandial triglyceridaemia during smoking may be explained either by a decreased absorption of fat or by an increased flow of triglycerides out of the circulation. It might be suggested that catechol amines released during smoking (Watts, 1960 ; Silvette, Larson, and Haag, 1961) cause the intestinal blood-vessels to contract (Ahlquist, 1948 ; Grayson and Swan, 1950), thus decreasing absorption. An increased activity of the pituitary-adrenocortical system evoked by smoking (Hökfelt, 1961) might also be involved here.

If the depressant effect of smoking on serum triglycerides is due to a more rapid flow of triglycerides out of the circulation, the increase of metabolic ingredients and circulatory parameters, known to be caused by smoking (Larson *et al.*, 1961a), may be responsible. It may be mentioned in passing that the present results might also be connected with an increased thyroid activity, pointed out in the older literature (Schlumm, 1932 ; Strauss, 1937 ; Hofstätter, 1934).

It has been observed that smoking increases the level of free fatty acids in the fasting state (Kershbaum *et al.*, 1961). The effect that smoking has in elevating the free fatty acids has been explained as occurring through the action of the catechol amines, which are known to cause a rise in plasma free fatty acids (Dole, 1956 ; Gordon and Cherkes, 1956 ; Shafrir and Steinberg, 1960). The situation in the present experiment is more complicated, because of the post-prandial period, which, apart from smoking, may cause changes in the plasma free fatty acids level (Gordon and Cherkes, 1956). There was, however, only a slight and insignificantly higher elevation in free fatty acids in smoking than in non-smoking subjects.

In previous studies the results of short-time smoking experiments indicate that smoking has scarcely any significant effect on the serum-cholesterol level (Strauss and Scheer, 1936 ; Short and Johnson, 1939 ; Högler, 1943 ; Page *et al.*, 1959 ; Kershbaum *et al.*, 1961). In the present study, also, no difference was noted during smoking.

Summary

Serum triglycerides, total cholesterol, and plasma-free fatty acids were determined in 20 young men who smoked heavily during the six hours after a fat meal and 20 who did not smoke.

The post-prandial rise in serum triglycerides was less in the smoking than in the non-smoking group. The difference was observed during the absorption phase, suggesting a decreased absorption of fat from the intestinal tract in connexion with heavy smoking. At six hours after the meal the triglyceridaemia had dropped to an equal level in both groups.

The plasma-free fatty acids underwent only an insignificantly higher rise in the smoking compared with the non-smoking group.

Serum cholesterol levels were unaffected by smoking.

References

Acheson, R. M., and Jessop, W. J. E. (1961). *Brit. med. J.*, **2**, 1108.
Ahlquist, R. P. (1948). *Amer. J. Physiol.*, **153**, 586.
Anderson, J. T., and Keys, A. (1956). *Clin. Chem.*, **2**, 145.
Becker, G. H., Meyer, J., and Necheles, H. (1950). *Gastroenterology*, **14**, 80.
Blackburn, H., Brozek, J., Taylor, H. L., and Keys, A. (1960). *Ann N.Y. Acad. Sci.*, **90**, 277.
Bronte-Stewart, B. (1961). *Brit. med. J.*, **1**, 379.
Dawber, T. R., Kannel, W. B., Revotskie, N., Stokes, J., Kagan, A., and Gordon, T. (1959). *Amer. J. publ. Hlth*, **49**, 1349.
Dole, V. P. (1956). *J. clin. Invest.*, **35**, 150.
Friberg, L., Kaij, L., Dencker, S. J., and Jonsson, E. (1959). *Brit. med. J.*, **1**, 1090.
Gofman, J. W., Lindgren, F. T., Strisower, B., deLalla, O., Glazier, F., and Tamplin, A. (1955). *Geriatrics*, **10**, 349.
Gordon, R. S., jun., and Cherkes, A. (1956). *J. clin. Invest.*, **35**, 206.
Grayson, J., and Swan, H. J. C. (1950). *Lancet*, **1**, 488.
Van Handel, E., and Zilversmit, D. B. (1957). *J. Lab. clin. Med.*, **50**, 152.
Heath, C. W. (1958). *Arch. intern. Med.*, **101**, 377.
Hofstätter, R. (1934). *Münch. med. Wschr.*, **81**, 439.
Högler, F. (1943). *Wien. med. Wschr.*, **93**, 309.
Hökfelt, B. (1961). *Acta med. scand.*, **170**, suppl. 369, p. 123.
Karvonen, M., Orma, E., Keys, A., Fidanza, F., and Brozek, J. (1959). *Lancet*, **1**, 492.
Kershbaum, A., Bellet, S., Dickstein, E. R., and Feinberg, L. J. (1961). *Circulat. Res.*, **9**, 631.
Konttinen, A. (1962). *Brit. med. J.*, **1**, 1115.
Krut, L. H., Perrin, M. J., and Bronte-Stewart, B. (1961). Ibid., **1**, 384.
Larson, P. S., Haag, H. B., and Silvette, H. (1961a). *Tobacco Experimental and Clinical Studies*. Baillière, Tindall and Cox, London.
—— —— —— (1961b). *Clin. Pharm. Ther.*, **2**, 80.
Lawton, M. P., and Phillips, R. W. (1956). *Amer. J. med. Sci.*, **232**, 397.
Marder, L., Becker, G. H., Maizel, B., and Necheles, H. (1952). *Gastroenterology*, **20**, 43.
Miller, D. C., Trulson, M. F., McCann, M. B., White, P. D., and Stare, F. J. (1958). *Ann. intern. Med.*, **49**, 1178.
Nikkilä, E. A., and Konttinen, A. (1962). *Lancet*, **1**, 1151.

Page, I. H., Lewis, L. A., and Moinuddin, M. (1959). *J. Amer. med. Ass.*, **171**, 1500.
Roth, G. M. (1960). *Mod. Con. cardiovasc. Dis.*, **29**, 605.
Schlumm, F. (1932). *Z. klin. Med.*, **120**, 648.
Shafrir, E., and Steinberg, D. (1960). *J. clin. Invest.*, **39**, 310.
Short, J. J., and Johnson, H. J. (1939). *J. Lab. clin. Med.*, **24**, 590.
Silvette, H., Larson, P. S., and Haag, H. B. (1961). *Arch. intern. Med.*, **107**, 915.
Strauss, L. H. (1937). *Z. ges. exp. Med.*, **100**, 209.
—— and Scheer, P. (1936). *Klin. Wschr.*, **15**, 187.
Thomas, C. B. (1958). *J. chron. Dis.*, **7**, 198.
—— (1960). *Ann. intern. Med.*, **53**, 697.
—— and Cohen, B. H. (1960). *Bull. Johns Hopk. Hosp.*, **106**, 205.
Trout, D. L., Estes, E. H., jun., and Friedberg, S. J. (1960). *J. Lipid Res.*, **1**, 199.
Watts, D. T. (1960). *Ann. N.Y. Acad. Sci.*, **90**, 74.

SMOKING HABITS OF MEDICAL AND NON-MEDICAL UNIVERSITY STAFF

CHANGES SINCE R.C.P. REPORT

BY

G. W. LYNCH, M.Sc.

M.R.C. Unit for Research on the Epidemiology of Psychiatric Illness, Department of Psychological Medicine, University of Edinburgh

On March 7, 1962, a Committee of the Royal College of Physicians published the report *Smoking and Health* which reviewed the evidence concerning the contribution of cigarette smoking to the occurrence of cancer of the lung and other diseases. It pronounced unequivocally that the case against prolonged and heavy cigarette smoking was proved beyond all reasonable doubt. This report received very widespread publicity in the press, on radio, and on television; more than ever before it appeared that public awareness had been alerted to this particular threat to health. Among the spate of exhortations a frequent theme was the need for teachers to encourage young people, by precept and example, not to acquire this habit.

It seemed opportune, therefore, to seize the occasion presented by this natural experiment in order (*a*) to ascertain the smoking habits of all members of a university teaching staff, (*b*) to inquire whether any significant change in habits of cigarette smoking occurred during the four weeks following the publication of the report, and (*c*) to discover whether any observed reduction in cigarette smoking was still in evidence after an interval of three months.

At the outset certain information about smoking habits was already available. The R.C.P. (1962) Report *Smoking and Health* includes details of the smoking habits of all men in the U.K. aged 35 and over in 1958 and those of a sample of male doctors in the same age-group. About one-quarter of U.K. males were non-smokers at that time and just over one-half smoked cigarettes only. In contrast, half of the male doctors were non-smokers and less than one-third smoked only cigarettes. The report concludes from this that doctors smoke less because they are specially aware of the harmful effects of cigarette smoking. It further conveys the impression that this low smoking rate is specific to doctors because it also states that the cigarette consumption in social classes I, II, III, and V are about the same.

Cartwright *et al.* (1959) found in their sample of Edinburgh adults of 21 years and more that approximately one-quarter of the men were non-smokers. This work suggested, however, that there was a difference in smoking habits within social classes and pointed out that the lowest proportion of smokers occurred in the professional and black-coated group. The same finding of relatively low proportions of smokers in the professional groups has been reported by McArthur *et al.* (1958) and Lilienfeld (1959). The latter found in his New York sample that less than one-third of professional people smoked. Heath (1958) stated that non-smokers tended to enter scientific careers. It seemed, therefore, that the analysis of the smoking habits of a university teaching staff would be of special interest in view of the conflicting evidence in respect of smoking habits in different social groups.

Method

In the third week of April, 1962, a questionary and an explanatory letter was mailed to each of the 1,190 members of the graduate staff of the University of Edinburgh. The letter referred to the interest felt in the effects of the R.C.P. Report, and the questionary inquired about the smoking habits in the first week of March and in the first week of April. Respondents were asked to give details of efforts they might have made to modify their smoking during this time. To this questionary 1,087 (91%) replied.

Three months after the publication of the report a second questionary was sent to those who had modified their smoking in the first week of April. This inquiry dealt with smoking habits in the first week of June and sought to determine the extent to which the modifications of April had been maintained. Respondents were specifically asked why they had changed their smoking pattern, since it was apparent that Lent, holidays, or illness, for example, could have been incidental and temporary reasons for modification, and quite unrelated to any possible effects of the Report. Reminders were sent where necessary, and the second questionary evoked a 90% response.

Results

As the report compares the smoking habits of male doctors with the rest of the population, in this survey the respondents have been classified as medical graduates and other (non-medical) graduates. Nine hundred and fifty male graduates replied, of whom 289 were medical and 661 were non-medical; 137 female graduates replied, of whom only 18 were medical and 119 were non-medical.

Smoking Habits in First Week of March

The smoking habits of the Edinburgh graduate staff before the publication of the report are shown in Table I. These are compared with the figures of the 1958 U.K. male population survey and the 1961 sample of doctors referred to in the report. The actual

TABLE I.—*Smoking Habits of Males Aged 35 and Over: Present Study Compared with Figures of R.C.P. Report*

	Non-Smokers		Cigarettes Only		Cigarettes/ Pipes/ Cigars		Pipes/ Cigars Only	
	No.	%	No.	%	No.	%	No.	%
Edin. medical ..	117	51	45	20	29	12	29	17
Edin. non-medical	207	47	121	27	35	8	77	18
U.K. males, 1958	—	24	—	54	—	10	—	12
Doctors, 1961 ..	—	50	—	29	—	10	—	11