

Relation of nicotine yield of cigarettes to blood nicotine concentrations in smokers

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Summary and conclusions

Blood nicotine and carboxyhaemoglobin (COHb) concentrations were studied in 330 smokers (206 women and 124 men). Blood nicotine concentrations in individual smokers varied from 25 to 414 nmol/l (4 to 72 ng/ml). The average concentration, 203 nmol/l (33 ng/ml), was the same in the men and the women, although cigarette consumption was higher in the men. Despite large differences in nicotine yield, there was no relation between blood nicotine concentration and the type of cigarette smoked: smokers of plain, untipped cigarettes (1.9 mg nicotine), cigarettes with unventilated filters (1.3 mg nicotine), and cigarettes with ventilated filters (0.8 mg nicotine) had similar blood nicotine concentrations. Cigarette consumption was also similar in these three groups. The correlation between blood nicotine concentration and nicotine yield of cigarette, though significant, was low (0.21, $p < 0.001$), showing that the nicotine yield of the cigarettes accounted for only 4.4% of the variation in blood nicotine concentrations. Similarly, the low correlation of 0.30 between COHb concentration and cigarette consumption suggests that cigarette consumption accounted for only 9.6% of the variation in the amount of smoke taken into the smoker's lungs.

These results suggest that the assumed health advantage of switching to lower-tar and lower-nicotine cigarettes may be largely offset by the tendency of smokers to compensate by increasing inhalation. The findings of epidemiological studies showing lower risks with filter-tipped cigarettes may be attributable to other factors such as biases in the samples and changes in the quality and carcinogenicity of tobacco tar, rather than to reduced tar intake.

Introduction

The hazards of cigarette smoking are widely believed to be reduced by lowering the tar and nicotine yields of cigarettes.¹⁻⁴ Many countries now publish official tables listing the yields, and various approaches have been considered to discourage the manufacture and use of high-tar brands. In Britain, for example, a supplementary tax was introduced in 1978 on cigarettes in the "high tar" category (29 mg and over).

This official "low-tar, low-nicotine" approach to safer cigarettes is based on two related assumptions: (i) that the amount of smoke taken in by smokers is largely determined by the standardised machine-smoked yields of the cigarettes; and (ii) that in consequence changing to lower-tar brands will result in roughly proportionate reductions in intake. The smoking

patterns of people, however, do not mirror those of the smoking machine. Individuals vary widely in how they puff and inhale, and, more importantly, unlike the machine, when switching brands they tend to modify their smoking pattern to maintain their intake of smoke at a fairly constant level.⁵⁻¹¹ It is important, therefore, to know to what extent the benefit of switching to lower-tar cigarettes is offset by the tendency of smokers to compensate by smoking more cigarettes or increasing inhalation.

Since 1974 we have been measuring blood nicotine and carboxyhaemoglobin (COHb) concentrations in smokers attending our smokers' clinic and in volunteers taking part in various experimental studies on smoking behaviour. This has provided data that have enabled us to examine the relation of the blood nicotine concentrations in smokers to the type of cigarettes they smoke.

Subjects and methods

Data on smoking habits and blood nicotine and COHb concentrations were available from 212 women and 151 men who attended the Maudsley Hospital smokers' clinic or volunteered for experimental studies on smoking at the addiction research unit. We excluded those who smoked cigars or hand-rolled cigarettes, leaving 206 women and 124 men who regularly smoked manufactured cigarettes for which tar and nicotine yields were available from the official tables published by the Department of Health. Carbon monoxide (CO) yields, though measured by the Government Chemist, were withheld by the Department of Health. The Tobacco Advisory Council, however, provided data on CO yields of some brands.

All subjects attended in the afternoon and had been instructed to smoke their usual brand in their usual way. On arrival they were asked to smoke one of their usual cigarettes, and a venous blood sample was taken two minutes after they had finished it. The samples were analysed for COHb by using an IL 182 CO-oximeter,¹² and plasma nicotine concentration was measured by gas chromatography.¹⁴

Results

Table 1 gives details of the cigarette consumption, type of cigarette smoked, and blood nicotine and COHb concentrations in the men and women. Cigarette consumption on day refers to the number of cigarettes smoked on the day of attendance up to the time of blood sampling. The standard deviations were similar in men and women. The lower mean COHb concentration in the men was partly due to the higher proportion who smoked plain cigarettes; the difference between men and women was not significant when the smokers of

TABLE 1—Cigarette consumption, type of cigarette smoked, and blood nicotine and COHb concentrations in men and women

	Men (n=124)	Women (n=206)	Significance of difference
% Smoking plain cigarettes	13.7	1.9	$\chi^2=18.0; p<0.001$
% Smoking low-nicotine cigarettes (<1.0 mg)	25.0	27.2	$\chi^2=0.2; NS$
Average cigarette consumption per day	36.2	32.6	$t=2.3; p<0.05$
Average cigarette consumption on day	20.7	18.2	$t=2.0; p<0.05$
Average tar yield of cigarettes (mg/cigarette)	17.3	15.6	$t=2.8; p<0.01$
Average nicotine yield of cigarettes (mg/cigarette)	1.3	1.2	$t=2.5; p<0.02$
Average blood nicotine (nmol/l)	205	200	$t=0.5; NS$
Average COHb (%)	7.8	8.6	$t=2.7; p<0.01$

Conversion: SI to traditional units—Blood nicotine: 1 nmol/12.0-16 ng/ml.

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