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The sugar intake of businessmen and its inverse relationship with relative weight*

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1. Yudkin's (1967) questionnaire on the dietary intake of sugar was given to 415 businessmen for self-administration.

2. The results showed an inverse relationship between sugar intake and relative weight (actual weight as a percentage of expected weight for height and age) and additional evidence suggests a direct relationship between sugar intake and adequate exercise.

3. The statement that 'sugar was restricted' was shown to be a factor of considerable importance affecting the reported level of sugar intake and should be taken into account when comparing different series.

4. The positive association between cigarette smoking and mean sugar consumption in this series was due to the low-sugar intake of ex-smokers.

5. In future studies on the role of sucrose in the aetiology of ischaemic disease, both smoking habits and levels of activity should be recorded.

The role of sucrose as an important factor in the aetiology of ischaemic heart disease is uncertain. Yudkin and his collaborators (Yudkin & Roddy, 1964; Yudkin & Morland, 1967) have reported results in support of the hypothesis that sucrose is important, while Burns-Cox, Doll & Ball (1969) and more recently the Medical Research Council Working-party (1970) failed to confirm this.

In their preliminary American study, Paul, MacMillan, McKean & Park (1968) reported a positive relationship between cigarette smoking and sugar intake. It has been suggested that a common association with cigarette smoking might account for any association found between sugar intake and ischaemic heart disease. Although a positive association between sugar intake and smoking has been reported by Burns-Cox *et al.* (1969) and by Bennett, Doll & Howell (1970), conflicting results were found by the Medical Research Council Working-party (1970).

The present study was designed in order to look at the sugar intake of a sample of the businessmen attending the Institute of Directors' Medical Centre, a group particularly thought to be at special risk for ischaemic heart disease. As in all diets recommended for weight loss the importance of restricting carbohydrates and especially sugar is stressed, the relationship between sugar intake and relative weight was examined. The relative weight is the actual weight expressed as a percentage of the expected weight, the expected weight being obtained from the tables of average weight by age and height of the Metropolitan Life Insurance Company of New York (1959). Other questions examined are what might be called the internal consistency of the questionnaire, the

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significance of voluntary restriction of sugar and how sugar intake changes with age. Finally, the relationships between sugar intake, cigarette smoking and coffee intake are examined in this sample of middle-aged men.

EXPERIMENTAL

The Institute of Directors' Medical Centre opened in London in June 1964, and by 1968 some 400 businessmen a month were attending for periodical medical examinations. The subjects come either as middle or senior executives from all types of firms dealing in commerce or trade such as finance, mining, transport, manufacturing or advertising or they come as individual members of the Institute of Directors, the necessary qualification in the latter event being an active directorship. The full range of the examinations undertaken and some of our earlier findings have been published previously (Pincherle & Wright, 1967, 1970; Wright, 1968; Richardson & Pincherle, 1969, 1971).

All male subjects attending for either a first or a repeat visit at the Medical Centre between October and November 1968 inclusive were selected for study. A self-administered questionnaire relating to dietary sugar intake, and designed by Professor John Yudkin (Yudkin, 1967), was handed by the reception staff to all 415 subjects attending. A brief note explaining the purpose of the study was attached to the questionnaire. This particular questionnaire was designed for self-administration to avoid observer bias; it has been widely used and successfully validated against dietary histories taken by experienced interviewers (Yudkin & Morland, 1967) and also against the more normal 7 d diary record (Yudkin & Roddy, 1966). However, it only measures the dietary sugar intake, and no allowance is made for sugar contained in alcoholic drinks. Consequently, no information was available on the total calorie intake of these subjects.

The total weekly intake of sucrose in beverages and the sucrose intake in other foods were calculated and, in addition, the number of cups of coffee consumed was recorded. Subjects who admitted either to restricting sweet or sugary foods or sugar, or to reducing the amount of sugar taken in tea or coffee, were classified as 'restrictors'. The length of time each subject had been restricting sugar was noted if available.

Replies to the question concerning the estimated weight change since the age of 25 were classified in one of four groups, namely not known, no weight change (this incuded seven subjects who stated they had lost weight), or weight gain of less than or more than 12·7 kg.

The questionnaire was supported by information obtained from standardized notes, compiled by the fifteen doctors who saw and examined the individual subjects. This included information on age, height, weight, smoking habits, the adequacy of the exercise of the subject and his past medical history.

There were certain conditions in which diet was altered or advice to change the diet was given. There were fifty-six subjects who gave a past history of diabetes, coronary thrombosis, treated hypertension, a cerebrovascular accident, peptic ulceration or operation, renal calculi or gout; they are called the 'unfit' group.

Table 1. *Mean sugar intake (g/week) by age, with and without restriction of sugar intake*

Age (years)	Restricting		Not restricting		Percentage restricting
	Mean	SE	Mean	SE	
< 35	336 (10)	66	575 (16)	54	38
35–44	307 (57)	30	585 (61)	36	48
45–54	266 (81)	19	509 (83)	29	49
55+	250 (52)	20	463 (47)	39	53
Total	277 (200)	13	526 (207)	19	49

Numbers of subjects in parentheses.
Difference in mean sugar intake between restrictors and non-restrictors: $t = 10{\cdot}9$, $P < 0{\cdot}001$.

Table 2. *Numbers of subjects restricting sugar intake by level of sugar intake*

Sugar intake (g/week)	Unfit group			Fit group			Whole group		
	R+	Total	% R	R+	Total	% R	R+	Total	% R
0–99	10	13	—	28	35	80	38	48	79
100–299	12	14	—	72	109	66	84	123	68
300–499	7	12	—	47	95	55	54	107	50
500–699	3	9	—	17	60	34	20	69	29
700+	1	8	—	3	52	6	4	60	7
Total	33	56	59	167	351	48	200	407	49

R+, number restricting; % R, percentage restricting.

Table 3. *Numbers of subjects restricting sugar intake by relative weight**

Relative weight	Unfit group			Fit group			Whole group		
	R+	Total	% R	R+	Total	% R	R+	Total	% R
< 90%	2	5	—	4	26	15	6	31	19
90–99%	5	12	—	36	93	39	41	105	39
100–109%	15	19	—	71	136	52	76	155	55
110–119%	5	12	—	38	69	55	43	81	53
120+%	6	8	—	18	27	68	24	35	69
Total	33	56	59	167	351	48	200	407	49

R+, number restricting; % R, percentage restricting.
* See p. 449 for definition.

RESULTS

The general response was good, with 407 out of 415 questionnaires available for analysis. The lower response rate to the questions concerning weight change since the age of 25 and the time for which sugar was restricted are indicated later.

The mean sugar intake fell with increasing age, and although the percentage of subjects restricting their sugar intake also increased with age, this did not account for the fall in mean sugar intake. Table 1 shows that the mean sugar intake fell with age

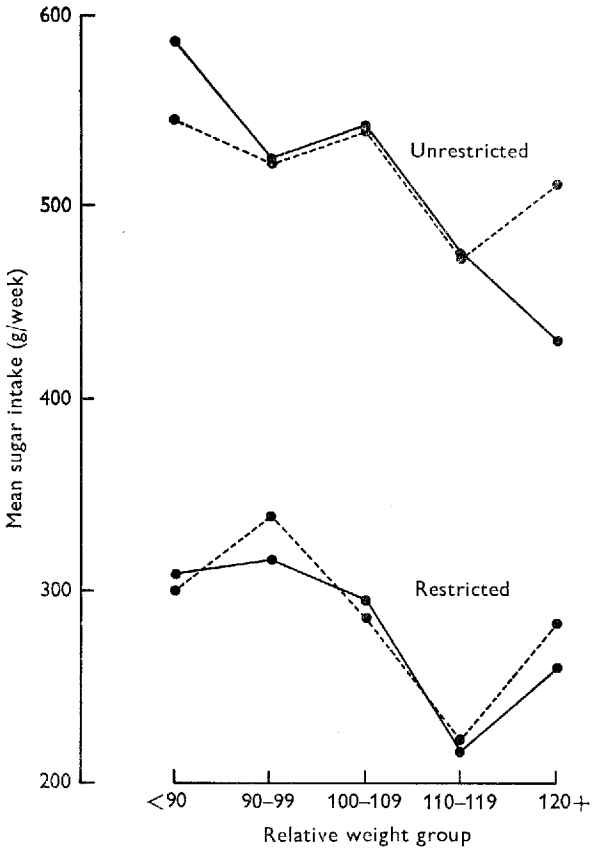

Fig. 1. Mean sugar intake in relative weight (see p. 449 for definition) groups by presence or absence of restriction of sugar intake for the whole group (—) and the fit group (– – –).

in both the restrictors and non-restrictors; it was significantly lower in the former ($P < 0{\cdot}001$).

Table 2 shows the number of subjects restricting sugar in the fit and unfit groups and their sugar intake. As would be expected, the percentage of restrictors fell with increasing sugar intake and the total percentage was higher in the unfit group.

Similarly, Table 3 shows the number of subjects restricting sugar and their relative weights. The salient point was the increase of sugar restriction with increasing weight.

Sugar intake and relative weight

The mean sugar intake in each relative weight group, for the whole sample with and without restriction of sugar and for the fit sample with and without restriction, is shown in Fig. 1. (The numbers in the unfit group were too small to allow comparison with the fit group, but there was no relationship between mean sugar intake and the relative weight in the unfit group.) The mean sugar intake fell with increasing relative weight, except for the most obese subjects. In each group the mean sugar intake was lower in those restricting sugar intake. Regression analysis shows that the

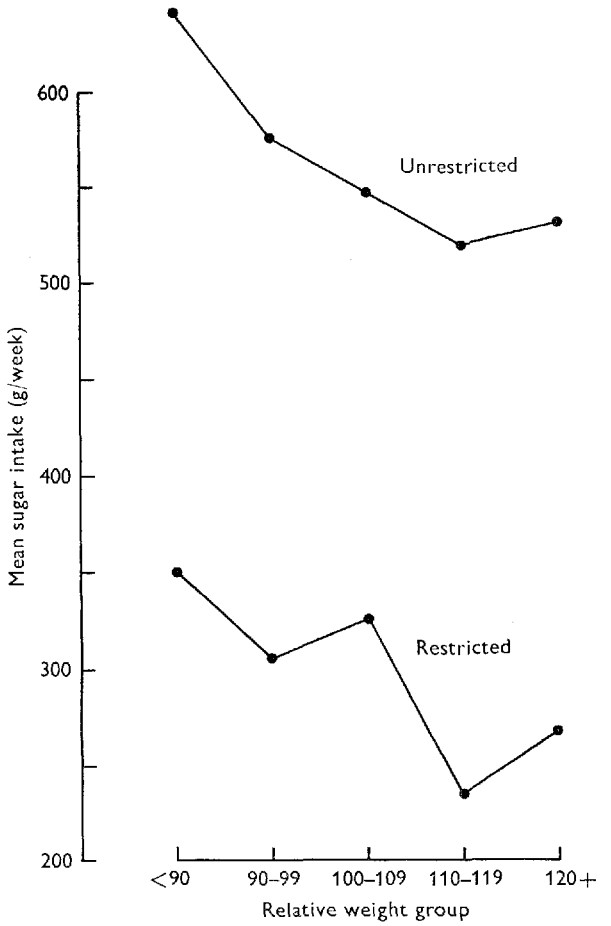

Fig. 2. Mean sugar intake in relative weight (see p. 449 for definition) groups by presence or absence of restriction of sugar intake for subjects attending for the first time.

inverse relationship between sugar intake and relative weight was highly significant for the whole group ($P < 0{\cdot}001$) and for the fit group ($P < 0{\cdot}001$). There was no trend of relative weight with age.

When the whole and the fit groups are divided by the presence or absence of sugar restriction (as in Fig. 1), the regression equations show that sugar intake fell significantly in each group ($P < 0{\cdot}05$) with increasing relative weight. It may justifiably be claimed that in this sample of businessmen those who were attending for a repeat visit may have been advised to reduce their weight. This could have led to bias in the results.

The number of subjects restricting their sugar intake at their first visit was only 5 % lower than the number restricting it at their second or subsequent visit. The mean sugar intake in each relative weight group for only those subjects attending for the first time is shown in Fig. 2. The inverse relationship between sugar intake and relative weight is apparent.

Table 4. *Percentage distribution of relative weight* by stated weight gain since age 25 years*

Estimated weight gain since age of 25 (kg)	No. of subjects	Present relative weight (%)				% Restricting sugar intake
		< 90	90–109	110–119	120+	
None or less	93	25	61	11	3	28 (30)
0·5–12·2	188	5	74	16	4	99 (52)
> 12·7	106	1	46	32	21	63 (59)
Not known	20	0	30	50	20	10 (50)

* See p. 449 for definition.

Table 5. *Mean relative weight* by exercise and restriction of sugar intake*

Subjects	Exercise adequate		Exercise inadequate	Total
Non-restrictors	100·6 (127)	$P < 0·025$	104·0 (80)	101·9 (207)
	$P < 0·001$	—	$P < 0·05$	$P < 0·001$
Restrictors	106·4 (102)	NS	107·5 (98)	106·9 (200)
Total	103·2 (229)	$P < 0·001$	105·9 (178)	—

Numbers of subjects given in parentheses. *P* values refer to differences between means on either side; NS, not significant.

* See p. 449 for definition.

For all the subjects attending for the first time the regression equation shows a significant fall in sugar intake with increasing relative weight ($P < 0·001$). However, when this group is divided into two by the presence or absence of sugar restriction (as in Fig. 2), the regression coefficients lose their significance ($r_1 = -0·15$, $r_2 = -0·14$, $P < 0·2$ in both instances). As there was no significant difference between the regression coefficients ($t = 0·21$), the lack of statistical significance may be attributed to the smaller numbers in each group, and not to any change in the relationship between sugar intake and relative weight in the two groups.

Table 4 shows the distribution of the responses to the question on estimated weight gain since the age of 25, and the percentage restricting their sugar intake in each group. This increased from 31% with no weight change reported to 60% for those reporting a weight increase of more than 12·7 kg. Weight change since the age of 25 was compared with relative weight, and this is also shown in Table 4. There was a good correlation between actual relative weight and stated weight gain since the age of 25 years ($\chi^2 = 86·3$ on 6 df, $P < 0·005$, excluding unknowns).

The calculated mean relative weights according to the adequacy or otherwise of exercise, and the presence or absence of sugar restriction, are shown in Table 5.

Sugar, coffee and cigarette consumption

In order to examine the relationships between sucrose, coffee and cigarette consumption, values for high and low levels have been arbitrarily allocated to each. Pipe and cigar smoking were not allowed for in these calculations. The sample was classi-

Table 6. *Relationship between sucrose intake, coffee consumption and cigarette smoking*

(A)	Never smoked		Ex-smokers		Current smokers	
	Low coffee	High coffee	Low coffee	High coffee	Low coffee	High coffee
Low sucrose	75	24	58	20	79	22
High sucrose	32	15	20	1	44	17
	0·61 (NS)		3·16 ($P = 0·058$)		0·47 (NS)	

(B)	Low coffee			High coffee		
	Never smoked	Ex-smokers	Current smokers	Never smoked	Ex-smokers	Current smokers
Low sucrose	75	58	79	24	20	22
High sucrose	32	20	44	15	1	17
	1·91 (NS)			8·16 ($P < 0·025$)		

Values of χ^2_c, calculated using Yates's correction for continuity, to test for association between coffee intake and sucrose intake within each smoking group.

Table 7. *Mean sugar intake by cigarette smoking category*

Smoking category	Never smoked	Ex-smokers	Current smokers
Mean sugar (g/week)	426 (147)	325 (98)	426 (162)
Mean age (years)	46·9	51·6	48·5
% Restricting sugar intake	49·7	54·5	42·9
Relative weight* (%)	104·1	105·7	104·5

Numbers of subjects in parentheses.
* See p. 449 for definition.

fied as 'current cigarette smokers', 'ex-smokers' or 'never smoked'. High sucrose intake was taken as more than 500 g/week, and high-coffee intake as four or more cups of coffee a day; the low level was less in each instance. The results are summarized in Table 6. A multiplicative model is assumed and by using a logarithmic transformation this can be rendered additive. Since this is a $3 \times 2 \times 2$ contingency table, the association between sucrose and coffee, between sucrose and cigarettes, and between coffee and cigarettes can be evaluated. It was analysed by the method of maximum likelihood, using a computer program for fitting the general model (Bock, 1966).

Statistical analysis showed that there was a significant three-factor interaction ($\chi^2 = 7·45$ on 2 df, $P < 0·025$). Therefore the association between sucrose and coffee intake was examined separately within each of the three smoking groups (Table 6A). This indicated an association only within the ex-smokers ($P = 0·058$).

Within the two coffee groups (Table 6B), there was a significant association in the high-coffee intake group and this again demonstrated that the ex-smokers differed from the two other smoking groups.

A similar analysis of a 2^3 contingency table of current cigarette smokers against those who have never smoked cigarettes showed no evidence of any association between coffee, cigarettes and smoking in this restricted sample.

Looking at the mean sugar intake by smoking category (Table 7), the main difference between smokers and non-smokers was due to the lower mean sugar intake of the ex-smokers. This was partly due to an age effect and partly due to the higher percentage of sugar restrictors in the ex-cigarette smoker group, but this may not be the whole explanation. There was no significant difference in mean relative weight between these three groups.

DISCUSSION

Previous workers (Papp, Padilla & Johnson, 1965; Paul *et al.* 1968) have examined the relationships between the sugar intake, weight and height, and obtained negative results. Finegan, Hickey, Maurer & Mulcahy (1968) calculated relative weight but made no comparisons.

The outstanding feature of the present investigations is the inverse relationship between sucrose intake and relative weight, which is contrary to expectation. This relationship was statistically significant and applied to both those restricting and those not restricting their sucrose intake in the whole group. The exclusion of the fifty-six subjects with a relevant past history (the unfit group) altered the values slightly (see Fig. 1), but the significance of the findings remains. This finding is also supported by the results when restricted to subjects attending for the first time.

There are no *a priori* reasons to suspect systematic bias within this group of businessmen in their responses to the questionnaire. The simplest hypothesis is to accept the results at their face value and to assume that there is, in fact, an inverse relationship between sugar intake and relative weight. This does not mean that previously the sugar intake was not much higher, as is suggested by the large differences in the mean sugar intake between those restricting and those not restricting sugar.

Salter (1969) also compared dietary sugar intake with relative weight. He used Yudkin's questionnaire, and the Metropolitan Life Insurance Company values for expected weight when studying 243 men, all volunteers, mainly working on the shop-floor in the manufacture of foodstuffs. He also found a general fall in sugar intake with increasing relative weight, although the two extremes of underweight and overweight both tended towards the mean in his study.

Howell & Wilson (1969) noted that there was no correlation between sugar intake and stated weight gain since the age of 25 years. Although the correlation between weight gain and relative weight is quite close, it appears that relative weight is the better index.

There are at least three possible explanations for the inverse relationship between sugar intake and relative weight. Subjects with low relative weight may in fact restrict without admitting; there is no evidence of this. Secondly, they may use sugar less efficiently and, thirdly, they may take considerably more exercise.

Although there is no evidence available on the total calorie intake of these businessmen, and it is a cross-sectional study, a decline in calorie intake with age, and also with increase in relative weight, could provide a partial explanation of the reduced sucrose intake. There is evidence which suggests that there is no simple relationship between calorie input, energy output and weight. The effects of calorie restriction on weight loss in obese patients are claimed to be less than expected (Bray, 1969), and Kekwick

& Pawan (1969) suggest that the body mass normally remains constant despite restriction in calorie intake and energy output, possibly mediated by a homoeostatic mechanism which regulates metabolism in adipose tissue. The training of athletes has been shown to affect in a major way the metabolism of fat and carbohydrate during and after exercise (Johnson, Walton, Krebs & Williamson, 1969).

It was shown by Yasin, Alderson, Marr, Pattison & Morris (1967) that total calorie input is related direct to activity, and skinfold thickness was inversely related (i.e. the less active tended to obesity) in their sample of middle-aged men, using both an 8 d activity record and self-assessment.

Of those subjects restricting sugar intake in the present study, only 51 % were thought to be taking adequate exercise against 62 % of the non-restrictors. This difference was statistically significant ($P < 0.05$). This finding suggests that the relative weight of those taking adequate exercise should be lower than those taking inadequate exercise, that the relative weight of those restricting should be higher than of those not restricting and also that the sugar intake of those taking adequate exercise should be higher than that of those not doing so.

The results confirm these suggestions (Table 5). Relative weight was significantly lower in those taking adequate exercise and significantly higher in those who restricted their sugar intake. The mean sugar intake was significantly higher in those who were judged to be taking adequate exercise ($P < 0.025$), but this finding may have been due to the lower precentage of restrictors.

These findings are of considerable interest because activity, whether at work (cf. Morris, Heady, Raffle, Roberts & Parks, 1953*a*, *b*; Skinner, Benson, McDonough & Hames, 1966), or apart from work (Dawber, Kannel & Friedman, 1966; Rose, 1969), is thought to protect against ischaemic disease, while sucrose intake, which is related direct to activity, is thought to predispose to ischaemic heart disease. Consequently any positive relationship between sucrose intake and ischaemic heart disease may well be important because the beneficial effects of 'activity' may mask the influence of sucrose *per se*. Paul *et al.* (1968) allowed for cigarette smoking in their prospective survey and recorded that individuals who developed myocardial infarcts or who died from coronary disease were found to have consumed more sucrose than a control group, but the difference was not statistically significant. This finding now assumes a new importance.

Howell & Wilson (1969) found the sugar intake in middle-aged men to be relatively constant for any given individual. Significant variation will complicate the assessment of the role of sucrose in the aetiology of ischaemic heart disease. Sugar intake falls with age and this is not only due to an increase in the percentage of sugar restrictors with age. Bennett *et al.* (1970) also noted a fall in sugar intake with age. In our sample, the majority of those restricting only admitted to a few years of sugar restriction. The exclusion of thirteen subjects who had dieted for 20 years or more (mean 30·5 years; standard deviation 11·1 years) left 145 subjects who answered this question. Their mean period of sugar restriction was 5·5 years with a standard deviation of 4·0 years. In the latter group there was no trend between relative weight and length of restriction time. This is additional evidence that the relationship between sugar intake and

Table 8. *Relationship between the mean sugar intake of whole groups of subjects and the percentage restricting their intake of sugar*

Reference	No. in fit groups	% Restricting	Mean sugar intake (g/week)
This paper	351	49	408
Howell & Wilson (1969)	1158	37	553
Burns-Cox *et al.* (1969) (hospital patients)	160	28	679

relative weight is a true one, because one would expect to find an exaggeration of restriction time if the heavier subjects were underestimating their sugar intake.

In comparison with the published results of Yudkin & Roddy, (1964), Marr & Heady (1964), Papp *et al.* (1965), Yudkin & Morland, (1967), Finegan *et al.* (1968), Paul *et al.* (1968), Burns-Cox *et al.* (1969) Howell & Wilson (1969) and Elwood, Waters, Moore & Sweetnam (1970), it is seen that the subjects of the present study had the lowest recorded sugar intake. One major reason for this result may lie in the fact that in this group of businessmen 49 % stated that they were restricting their sugar intake. In Howell & Wilson's subjects the percentage was 37 %, whereas in those of Burns-Cox *et al.* it was only 25–28 % (Table 8). The mean sugar intake falls with an increasing percentage of numbers restricting their sugar intake, but the samples are not necessarily comparable because of possible differences in age and social class. Burns-Cox *et al.* (1969) noted that in hospital there is a social-class gradient in sugar consumption. Bennett *et al.* (1970) confirmed that there is a trend of increased sugar consumption with lower social class. The low sucrose intake might be related to a higher standard of living in this group of businessmen who belong to social class I or II. In addition, the group examined had chosen to attend for a health check and may have been health-conscious. Consequently they may have made spontaneous efforts to stop smoking and to lose weight.

To make a valid comparison with other groups both the total sugar intake and its percentage contribution to total calories need to be known, together with the age and social-class structure of the sample and the percentage restricting their sugar consumption. In general, in all diets advised for weight reduction stress is laid on the restriction of carbohydrates, and especially of sugar. It would appear that this advice is taken to heart by the overweight, especially by those who admit to sugar restriction, but also by those who do not admit to it.

Both Paul *et al.* (1968) and Burns-Cox *et al.* (1969) showed a weak positive association between cigarette smoking and consumption of sugar, and this was confirmed in the studies of Bennett *et al.* (1970) and in that of Elwood *et al.* (1970) for female subjects only. The Medical Research Council Working-party (1970) did not find this relationship, except in one centre where they thought that the slightly higher sugar intake in patients with myocardial infarction was likely to have been due to an association between the consumption of sugar and the smoking of cigarettes. The lower mean sugar intake of ex-cigarette smokers accounts for the association between cigarette smoking and sugar intake in the present study. Among the subjects of

Burns-Cox *et al.* (1969), ex-smokers had the lowest recorded sugar intake; this is also true of male employees of the UK Atomic Energy Authority (Bennett *et al.* 1970). Both these samples, however, allowed for pipe and cigar smoking.

Approximately one in three of our businessmen who successfully gave up cigarette smoking put on weight, a proportion also found by McKennell & Thomas (1967). In this highly motivated sample of businessmen, this stimulus is probably sufficient to account for their lower sugar intake. In the present study, there was no difference in mean sugar intake between current cigarette smokers and those who had never smoked cigarettes.

Similarly, there was no significant difference in mean relative weight between those who had never smoked, ex-smokers and current cigarette smokers (Table 7), and this was confirmed in a separate group of 2000 businessmen (Pincherle, 1971). These findings are at variance with those of Khosla & Lowe (1971), who found a considerable difference between the body-weights of smokers and non-smokers.

However, the two studies are not directly comparable because the definition of smoking is limited to cigarette smoking in this study whereas all forms of smoking were encompassed by Khosla & Lowe (1971). Another important difference is one of social class, the subjects of the present study being almost totally from class I or II, whereas the South Wales series is presumably almost entirely social classes IV and V.

These findings underline the difficulty of the interpretation of epidemiological findings and emphasize the importance of measuring all relevant criteria in view of the unexpected interrelations between them.

Conclusion

These results suggest that levels of activity, relative weight and smoking history should be included in the analysis of epidemiological studies on the role of sucrose in the aetiology of ischaemic heart disease. Neglect of this factor may yield a false negative result for the relationship between sugar intake and ischaemic heart disease.

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