BLOOD SUGAR IN EXECUTIVES

An observational study

P. PSAILA-SAVONA,
M.D.(MALTA), M.SC.(LOND.), D.P.H.(ST. AND.), D.I.H.(LOND.)
Medical Officer of Health, Malta.

Summary

The blood sugars of presumptively healthy male executives attending for a routine check up have been analysed. One group of 4227 men had their random blood sugar measured and another of 634 had blood sugar measured two hours after a 50 g. glucose load. The two groups were comparable in all respects except for mean and variance of blood sugar and the incidence of glycosuria.

Mean blood sugar increases with age. This effect may be altered by glucose loading. It may be due to an increase in pathological hyperglycaemia rather than to a pathological effect of age. A family history of diabetes leads to higher mean blood sugar levels.

No correlation was found between relative weight, exercise, stress, cigarette smoking and alcohol consumption.

The results are compared with those from other surveys. They support the suggestion that executives as a group may have different mean blood sugar levels from other occupational groups. However, owing to problems of selection and different methodology, this cannot be regarded as proved.

Introduction

The Institute of Directors Medical Centre was opened in June 1964 with the aim of providing health check ups for business executives. Executives of varying status from companies of all sizes are seen and they come either as 'individuals' at their own request or as 'groups' referred by their firms.

The examination includes a detailed history, a complete physical examination and a battery of screening tests. Chemical pathology is done by one laboratory using auto-analyser processing while X-rays and E.C.Gs. are reported on by the Centre's consultants. Great pains are taken to see that reasonable uniformity is obtained and kept throughout.

This report presents a study of the blood sugars of 4861 reputedly healthy male executives attending the Medical Centre for the first time for a routine health check up.

It is to be emphasised that the group studied may not be representative of the entire executive population since many individuals have come for examination of their own free will. Such self-selected people may be far from representative of the group from which they have been drawn.

It was decided to perform blood sugar estimations routinely only in 1967. At first a Lucozade drink containing 50 gms of glucose was given followed by blood sugar estimation 2 hours later. For a variety of reasons this method was abandoned and a random blood sugar level was taken. The sample studied therefore consists of 4227 random (Non-Lucozade group) and 634 loaded (Lucozade group) examinations.

These two groups were comparable in respect of age, relative weight, cigarette consumption, status and stress but they were found to differ significantly in the mean and variance of their blood sugars *(Table 1)* and in the incidence of glycosuria *(Table 2)*.

Glycosuria

	+	−	*Total*
Non-Lucozade	93 (2%)	4143 (98%)	4227
Lucozade	81 (13%)	553 (87%)	634

$x^2 = 178.6$ on 1° freedom; $P < 0.001$

Table 2. Presence/Absence of Glycosuria in Lucozade and Non-Lucozade Groups.

Blood Sugar by Age

Evidence has accumulated in the past few years to suggest that in the general population, blood sugar increases with advancing age [Dozefsky *et al* (1965), Hayner *et al* (1965), Spiegelman and Marks (1946), Cheraskin *et al* (1966)]. This has been confirmed in the present study in the Non-Lucozade group but not in the Lucozade group *(Table 3)*.

Age has been recorded as the age at last birthday. The mean age for the Non-Lucozade group is 46.32 and for the Lucozade group it is 46.13.

In the Non-Lucozade group, the blood sugar levels vary widely; 10 persons have a level less than 60 mg.% and 8 a level of over 200 mg.%. The mean blood sugar is 94.81 mg.% with a standard deviation of 15.13. The relationship between age and blood sugar levels is shown graphically in *Fig. 1*.

There is a difference of 11.93 mg.% in the blood sugar between the oldest and the youngest age group and this is statistically significant ($P < 0.01$). The corre-

Blood sugar in mg%

	<69	*—79*	*—89*	*—99*	*—109*	*—119*	*—139*	*140+*	*Total*
Non-Lucozade	36 (1)	308 (7)	1272 (30)	1239 (29)	880 (21)	275 (7)	164 (4)	53 (1)	4227
Lucozade	71 (11)	135 (21)	157 (25)	106 (17)	84 (13)	35 (6)	27 (5)	19 (2)	634

$x^2 = 444.2$ on 7° freedom; $P < 0.001$

Table 1. The Blood Sugar Distribution of Lucozade and Non-Lucozade Groups. Figures in brackets are percentages.

Age	Non-Lucozade Nos.	Non-Lucozade Mean Blood Sugar	Non-Lucozade S.D.	Lucozade Nos.	Lucozade Mean Blood Sugar	Lucozade S.D.
<25	33	89.12	13,33	4	102.50	25.84
25–34	512	92.12	13.33	61	86.97	22.23
35–44	1421	93.74	13.65	245	90.67	19.45
45–54	1414	95.07	15.50	192	89.09	23.66
55–64	762	97.18	17.61	118	88.53	21.63
65+	84	101.05	19.52	14	101.00	34.88
Total	4227	94.81	15.13	634	89.74	21.94

Table 3. Mean Blood Sugars and standard Deviations by Age in Lucozade and Non-Lucozade Groups.

lation coefficient r = 0.11, the regression coefficient b = 0.16 and 't' = 7.05 ($P < 0.001$). These results are in very close accord with some of the previous studies. Cheraskin *et al* (1966) in a diabetes detection drive in Birmingham, Alabama give a correlation coefficient of r = 0.1141 and $P < 0.0001$.

Furthermore, it is to be noted, as was indeed noted in the above mentioned Alabama survey, that the standard deviations for the age groups also increase with advancing age (if allowance is made for the exception in the 25-34 age group) *(Table 3)*. This means that in the later years there is a greater tendency for the blood sugar to spread from the mean than in the earlier years.

The significance of this finding needs some discussion. It has often been postulated that the increase of blood sugar with advancing age is a physiological process. This may very well be, but doubts have been recently shed by Cheraskin (1966) and the present study seems to confirm them. *Figure 2* shows that at one standard deviation away and below the mean, the difference between blood sugars in the over 65s and the under 25s is 5.74 (A) and if the under 25s are excluded the difference between the highest and the lowest levels is merely 1.96 mg.%. On the other

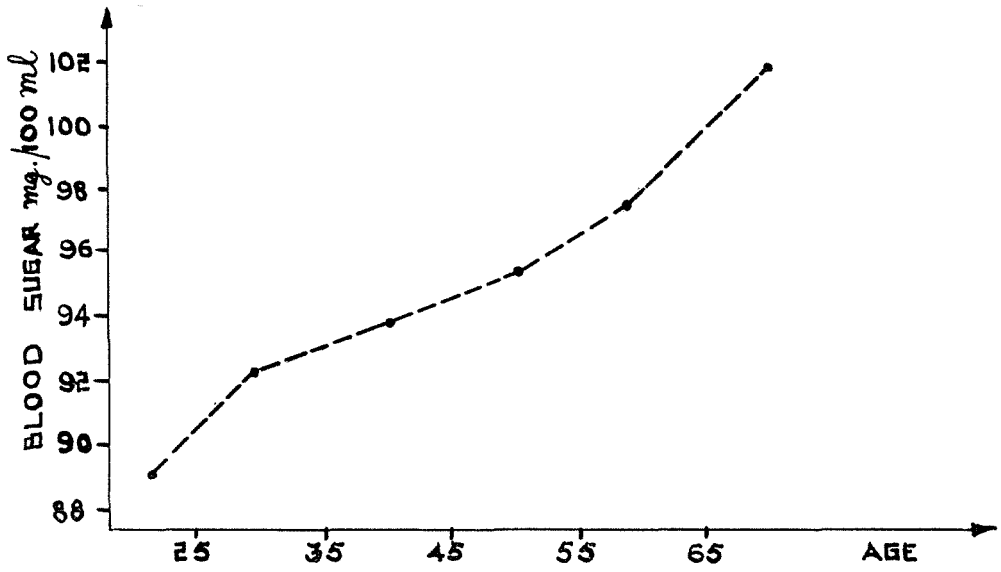

Fig. 1. Correlation between Blood Sugar and Age in Non-Lucozade Groups.

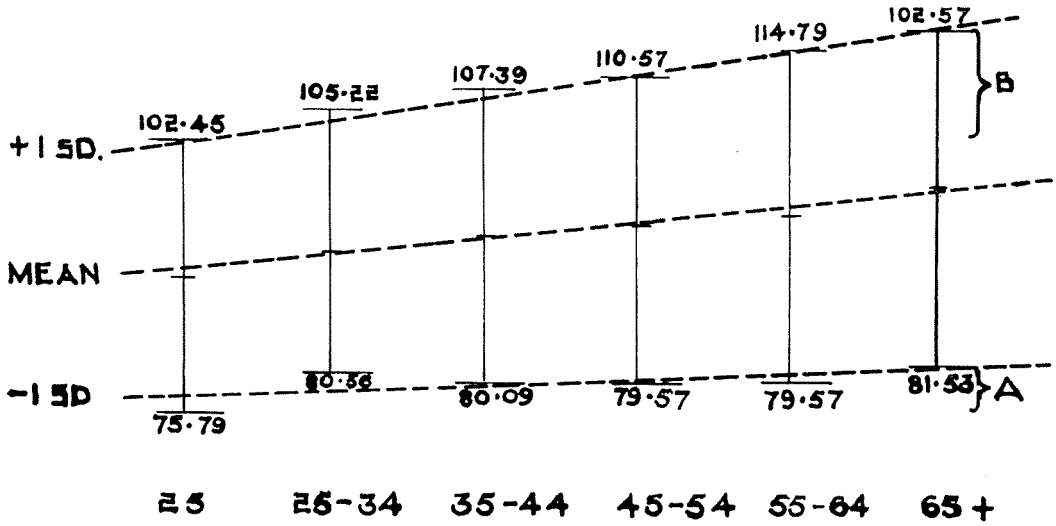

Fig. 2. Mean Blood Sugars ∓ 1 Standard Deviation in Non-Lucozade Group. (A=81.53 — 75.59 = 5.74; B = 120.57 — 102.45 = 18.12).

hand, at 1 standard deviation away from and above the mean, the difference is 18.12 mg.% (B) – a high figure in comparison. In other words, the gradient of the blood sugars at +1 S.D. is much steeper than the gradient at –1 S.D. so that the mean blood sugar is not being *pushed* upwards by an individual increase in each blood sugar but is being *pulled* upwards by an ever-increasing number of hyperglycaemics appearing with each successive age group.

Kent *et al* (1968) in an analysis of tests for diabetes in 250,000 persons screened for diabetes noted that "Although the results showed that each ascending decade of age had a higher percentage of persons who were considered to have diabetes, the majority of persons even in their 80's had normal tests". This seems to support the theory that hyperglycaemia becomes a relatively more common pathological finding with advancing age and therefore an increasing blood glucose is not part of the phenomenon of physiological ageing.

In the Lucozade group, the blood sugar levels also vary widely; 8 persons have a level less than 60 mg.% and 3 a level of over 200 mg.%. The mean blood sugar is 89.74 mg.% with a standard deviation of 21.94. No relationship between blood sugar and increasing age could be detected. Apparently loading with sugar counteracts the effects of age on blood sugar. No explanation for this is readily available.

It is interesting to note that the mean blood sugar for the Lucozade is significantly lower than that for the Non-Lucozade group, and that the distribution curves *(Fig. 3)* for the 2 groups show the following differences:

(a) The Lucozade curve has a shorter mode.

(b) The Lucozade curve is wider and especially so at the base.

(c) The Lucozade curve is shifted to the left of the Non-Lucozade one.

Such differences may be explained if it is remembered that

(i) In the non-diabetic individual, loading with sugar tends to lower the blood sugar below the fasting level at the end of 2 hours.

(ii) In the diabetic, after loading with sugar there is a tendency for the blood sugar to remain above the fasting level (and very often much higher).

As the fasting sugar is on an average lower than the random blood sugar, the first statement may explain the shorter mode and the shift to the left of the Lucozade group as compared with the

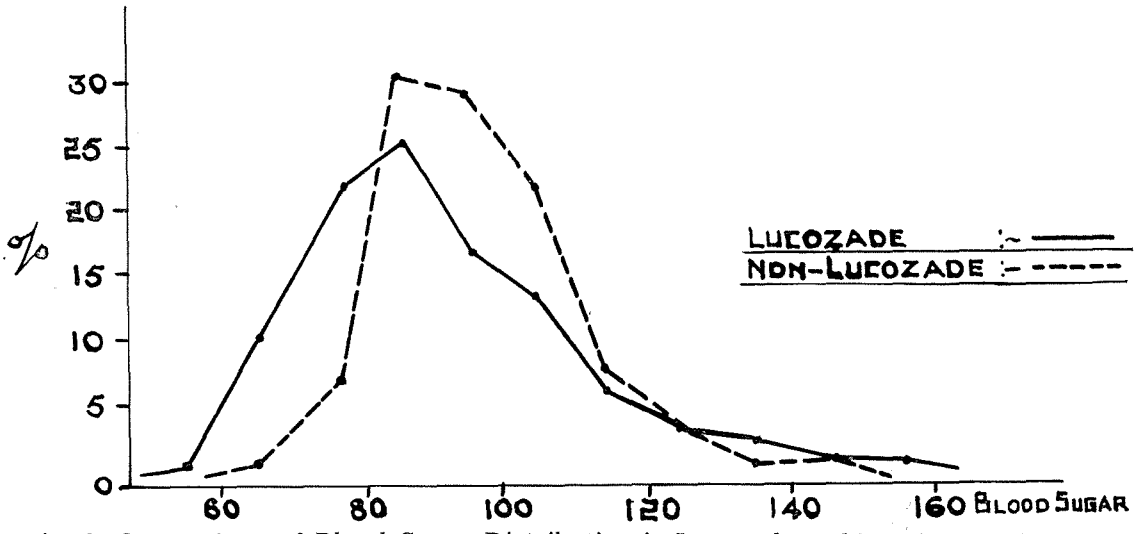

Fig. 3. Comparison of Blood Sugar Distribution in Lucozade and Non-Lucozade Groups.

Non-Lucozade one — this occurring in the range of 'normal' blood sugar levels. The second statement explains the shift to the right at the base in the higher range of blood sugar (? the abnormally high ones).

Blood Sugar by Weight

Weight has been recorded as Relative Weight, defined here as observed weight (with minimal clothing on) expressed as a percentage of the expected weight. Levels for the latter have been obtained from the American Metropolitan Life Insurance Company figures corrected for height and age.

Table 4 sets out the relevant details for both the Lucozade and the Non-Lucozade groups. It will be seen that 2651 (62%) in the Non-Lucozade and 381 (60%) in the Lucozade group are within ∓ 10% of the expected weight; 27% and 29% respectively are overweight and what is very surprising for an affluent occupation 10% and 11% respectively are underweight (at least by American standards).

No pattern in the mean blood sugars for the different relative weights was discerned in either group. There is a higher sugar level for the grossly obese (130 + %) and a lower blood sugar in the underweight (<80%) than for any other

	Non-Lucozade			*Lucozade*		
Relative Weight	*Mean Blood Sugar*	*Nos.*	*S.D.*	*Mean Blood Sugar*	*Nos.*	*S.D.*
<80%	93.89	64	14.77	86.62	16	17.65
80–89	95.86	346	18.79	89.92	50	16.62
90–99	94.79	1155	14.29	88.21	154	22.55
100–109	94.52	1496	14.09	90.14	227	23.16
110–119	94.40	795	13.80	91.02	123	20.67
120–129	95.42	274	6.98	89.07	44	24.20
130+	98.14	96	23.10	92.65	20	22.19
Total	94.81	4226	15.13	89.74	634	21.94

Table 4. Mean Blood Sugars and Standard Deviations by Relative Weight in Lucozade and Non-Lucozade Groups.

weights in both groups, but such differences have not been found to be significant at the 0.05 level.

Previous studies have observed a modest correlation between obesity and glucose levels (Hollister *et al* 1967; Cheraskin *et al* 1967; Albrink and Meigs 1964) and it was expected that a better relationship between blood sugar and weight should have been obtained here. It is possible, however, that weight when denuded of its height and age bias (as has been done in this study) bears no relationship to blood sugar.

It is significant to compare such a finding with that noted by O'Sullivan *et al* in the Oxford Epidemiological Study (1965). "The relationship of the initial postprandial blood sugar to body weight was found to be insignificant by a multiple regression analysis which included age, height and sex as other variables."

Family History

A detailed family history of disease of each executive was taken at the medical examination. Out of the Non-Lucozade group of 4227, 105 gave a family history of diabetes. The mean blood sugar for these was 99.91 mg.% with a standard deviation of 15.13 as against 94.68 mg.% and a standard deviation of 14.75 for those with a negative history. This difference is very highly significant (P <0.001).

In the Lucozade group, the mean blood sugar level for those with a positive history was 98.75 mg.% with standard deviation of 21.36 as against 89.37 and 21.94 respectively for those with a negative history. This is significant at the 0.05 level. Table 5 summarises the data.

Except for the under 25's and the over 65's, where the mean blood sugar levels were either unobtainable or unreliable (too few executives), the higher level in those with a positive history was evident throughout the age groups in the Non-Lucozade group *(Table 6)*. Small numbers in some of the age groups also accounted for similarly unreliable means in the Lucozade group but on the whole, the same trend was noticeable.

Status

Status was recorded in 3 grades — top, middle and junior according to the position the executive held in the company. In the Non-Lucozade group, status was not recorded in 24; 2721 held top, 1441 middle and 41 junior positions. In the Lucozade group, status was not recorded in 3; 435 held top, 195 middle and only 1 a junior post.

The middle executive has a signific-

	Mean Blood Sugar Family History				
	+	–	*Difference*	*"t"*	*P*
Non-Lucozade	99.91	94.68	5.23	3.50	<0.001
Lucozade	98.75	89.37	9.38	2.10	<0.05
Total	99.61	94.00	5.61	3.88	<0.001

Table 5. Mean Blood Sugar in Lucozade and Non-Lucozade Groups by Family History of Diabetes.

		Age					
		<25	*—34*	*—44*	*—54*	*—64*	*65+*
Family	+	*	94.31	99.46	97.19	112.57	96.54*
History	–	89.12	92.85	93.60	95.01	96.85	101.16

Table 6. Mean Blood Sugar by Age and Family History of Diabetes.
* mean blood sugar unobtainable or unreliable.

antly higher mean blood sugar than either the top ($P < 0.05$) or the junior executive ($P < 0.01$) in the Non-Lucozade group. In the loaded group, a similar trend is apparent but the figures are too small to give a significant result. Table 7 shows the relevant data for the Non-Lucozade group

Status	*Number*	*Mean Blood Sugar*	*Standard Deviation*
Top	2721 (64%)	94.54	15.18
Middle	1441 (34%)	95.56	15.08
Junior	41 (1%)	89.98	12.14
Middle vs Top		"t"=2.07;	P<0.05
Middle vs Junior		"t"=2.88;	P<0.01

Table 7. Mean Blood Sugar by Executive Status in the Non-Lucozade Group.

for whom the rest of this part of the discussion applies. The difference in sugar levels between the middle and junior grades can presumably be explained as an age effect. In the junior grade, the majority (68%) of the population are under 35 years while in the middle grade, the majority (81%) are over 35. But age does not explain the difference in the sugar levels between the middle and the top executives since the age distributions of the two are similar. This is shown even better in Table 8 where it can be seen that age for age, except in the under 25's where the number of executives is too small to give reliable means, the mean blood sugar for the middle is consistently higher than that for the top executive. The possibility of a genetic difference in the two cannot be excluded. It may be that the executives who are destined to go to the top are made of a different fibre from the executives who can only make middle grade.

Other Parameters

No significant relationship was noted between blood sugar and exercise, stress, cigarette smoking or alcohol consumption.

Executives: A special Population?

It was noticed in the Bedford survey (Butterfield *et al* 1964) that when the recognized diabetics and females in the town had been excluded, the incidence of glycosuria was 5.9% — three times the incidence in our corresponding Non-Lucozade population.

When a representative sample of the population of Bedford was loaded with glucose (as indeed was done in our Lucozade group) the incidence was found to be 30%. In the executive population, the figure is 13%.

After loading in the Bedford survey, 12-14% of a supposedly normal adult population showed a blood sugar of more than 120 mg/100mls. The corresponding Lucozade figure is 7.25% *(Table 9)*.

	Executives	*Bedford*
Random Glycosurics	2%	5.9%
Loaded Glycosurics	13%	30%
Loaded Blood Sugar > 120 mg.	7.25%	12–14%

Table 9. Comparison between Executive and Bedford Populations.

It may be argued that in the Bedford survey, estimations of blood sugar were made on capillary blood whereas in our study, they were made on venous samples. This might explain the discrepancy in the figures; however, the same cannot be said for the difference in incidences of glycosuria since the same method of examination of the urine has been employed. The age structure of the two populations is, moreover, very similar.

Status	*<25*	*—34*	*—44*	*—54*	*—64*	*65+*
Top	*	92.42	93.37	94.35	96.27	101.01
Middle	87.36	93.53	94.42	96.27	100.35	106.86

Table 8. Mean Blood Sugar by Age and Executive Status.
* mean probably unreliable.

Do executives really get less glycosuria and lower blood sugar on average than the general population? Or is it that executives, being perhaps more conscious of their health, undertake more frequently routine medical examinations, glycosuria and hyperglycaemia are detected earlier and therefore fewer unrecognized cases enter into studies of this kind?

If, on the other hand, a true difference in incidence exists, is this due to a change in social patterns? How much is it due to exercise or lack of it, and/or to eating habits in affluent conditions? Are there inherent metabolic or genetic factors?

To answer these questions, an adequate comparison of a large enough age-standardised, representative sample of the executive population with a similar sample, or samples, of non-executives needs to be made.

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