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Weight-height indices*

Choice of the most suitable index and its association with selected variables among 10,000 adult males of heterogeneous origin

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SUMMARY

Weight/height^2 (W/H^2) was found to be the 'best' power-type weight-height index for men of all ages above 40 when examining the 10,000 Israel civil servants. These were all men aged 40 and over from six major areas of birth in Europe, North Africa, the Middle East, and Israel. This finding confirms other work done with widely different cultural groups.

The association of this W/H^2 index was examined in respect of several demographic and other socio-economic variables. The major findings were as follows:

W/H^2 rises with age until 50, then plateaus until 60, after which there appears to be a slight drop.

Israeli-born subjects showed the highest index and those born in the Middle East the lowest index.

A general increase in the index occurred over the five years of observation except at age 60 and over.

Low values were associated with 'professionals' on the one hand, and 'labourers' and those with 'no schooling' on the other.

Immigrants who came during or immediately after the second world war were the 'leanest' of all immigrants when examined about 20 years later.

The previous finding that cigarette smokers (particularly medium and heavy smokers) showed a low value in comparison with ex-smokers and those who had never smoked was confirmed.

Ex-smokers, particularly those who had previously smoked heavily, were more overweight than smokers and those who had never smoked.

The findings suggest that ex-smokers gain weight fairly rapidly and then gradually reduce to the weight of those who never smoked but not to that of smokers. In order to verify this finding, a follow-up of ex-smokers is needed.

Self-reported physical activity was associated with a lower W/H^2 index for smokers, and to a lesser extent for ex-smokers, but did not seem to have an appreciable effect on those who had never smoked.

Dietary variables as measured by our questionnaire were not found to be associated with the W/H^2 index.

INTRODUCTION

During the past 10 years increasing attention has been paid to properties of indices based on weight and height. Obesity or overweight has been established as a risk factor in coronary heart disease in our study as well as in several other studies (Shapiro, Weinblatt, Frank, and Sager, 1969; Gordon and Kannel, 1973; Medalie *et al.*, 1973a, b), in diabetes (West and Kalbfleisch, 1966; Medalie *et al.*, 1974), and in hypertension (Kahn *et al.*, 1972). Indices of obesity or overweight were generally based on one of two systems: (1) relative weight, namely the ratio of a person's weight to a standard weight for his sex and height (sometimes an additional characteristic), and (2) W/H^p (weight divided by the p^{th} power of height).

Presented here is the evaluation of the 'best' power-type index, standard weight, and the correlation between the different accepted W/H^p indices and skinfolds in the population of the Israeli Ischemic Heart Disease Project. The association of this 'best' index with selected variables (age, occupation, education, physical activity, diet, and smoking) of the study population is also reviewed.

SOURCE OF DATA

The Israeli Ischemic Heart Disease Project included three extensive examinations (1963, 1965, and 1968) of approximately 10,000 men aged 40 and over in 1963. The examinees were civil service workers and municipal employees in the areas of Jerusalem, Tel Aviv, and Haifa. The study, described in detail by Groen *et al.* (1968), involved a stratified sampling of subjects from six regions of birth—Israel (including former boundaries of Palestine), Eastern Europe, Central Europe, Southeastern Europe, the Middle East, and North Africa. Different sampling ratios, varying from 1 : 1 to 1 : 4, were used as the utilization of a uniform sampling ratio would have produced insufficient numbers for

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follow-up within some regions of birth over the subsequent five years.

Of the 10,059 subjects included in the current follow-up and analysis, weight and height were recorded for 10,034. Subscapular and triceps skinfolds were recorded for 9,760 and 9,511 respectively. All four measurements were recorded for 9,475 subjects.

Height was recorded to the nearest centimetre with the subject standing, without shoes, determining where the right angle of the levelling triangle met the measuring rod. One of the flat sides of the triangle rested on the subject's head and the other on the upright measuring rod. Weight was recorded to the nearest kilogram with the subject wearing trousers only.

Triceps skinfold was recorded by Lange skinfold caliper (Cambridge Scientific Industries Inc., Cambridge, Md, USA) and was measured half way down the right arm between the tip of the acromion and the top of the olecranon, with the fold picked up in a line passing directly up the arm from the tip of the olecranon process. The arm was relaxed at the side, care being taken to locate the site right on the back of the arm, truly above the olecranon.

Subscapular skinfold was recorded by the same caliper and was measured just below the angle of the left scapula (shoulder and arm relaxed), the fold being picked up in vertical line.

Results

1. The most Suitable Weight-height Index

The correlations among weight, height, and subscapular and triceps skinfolds, and their correlations with various indices of weight-height, are shown in Table I, using the results from studies in Birmingham (Khosla and Lowe, 1967), Framingham (Florey, 1970), and Israeli studies. The matrices of correlations are remarkably similar from all three studies. *The weight-height index showing the lowest correlation with height is W/H^2 in all three studies.* A range of values is given for Birmingham as the overall figures for all ages combined have not been published.

Table II shows the mean height, mean weight, coefficient of regression (b) of weight on height, and $p = b\frac{\bar{H}}{\bar{W}}$ for each of 18 age-area groups and for the total Israeli study population. With the regression in the form $W(H) = \bar{W} + b(H - \bar{H})$, $\bar{W}$ is, of course, the intercept of the regression equation. The above p is the one that makes an index W/H^p uncorrelated with height.

It is easily seen that if an integer number for p were to be chosen, 2 would be the obvious choice. It is an interesting observation that while the 40-49 age group 'produces' p of 1·82-2·24 in the six

Table I

CORRELATIONS AMONG HEIGHT, WEIGHT, SKINFOLDS AND WEIGHT-HEIGHT INDICES RESULTS FROM BIRMINGHAM[1], FRAMINGHAM[2], AND THE ISRAEL[3] STUDIES (MALES ONLY)

	Study	Height	Weight	Triceps Skinfold**	Subscapular Skinfold**
W/H	Birmingham	0·19-0·37	0·96-0·97	—	—
	Framingham	0·22	0·96	0·47	0·65
	Israel	0·28	0·96	0·42	0·60
W/H^2	Birmingham	−0·06-0·02	0·83-0·85	—	—
	Framingham	−0·08	0·83	0·46	0·66
	Israel	−0·03	0·83	0·40	0·60
$H/\sqrt[3]{W^2}$ ..	Birmingham	−0·24- −0·33	0·60-0·68	—	—
	Framingham	0·36	−0·64	−0·44	−0·64
	Israel	0·31	−0·64	−0·36	−0·56
Weight	Birmingham	0·43-0·59	—	—	—
	Framingham	0·48	—	—	0·61
	Israel	0·52	—	—	0·54
Height	Birmingham	—	—	—	—
	Framingham	—	—	—	0·04
	Israel	—	—	—	0·05
Triceps skinfold** ..	Birmingham	—	—	—	—
	Framingham	0·12	0·44	—	0·73
	Israel	0·09	0·39	—	0·58

* For Birmingham: W/H^3, the correlation thus being of opposite sign but same size of order
** Not measured in Birmingham
1 5,122 males aged 15-64
2 2,033 males aged 40 and over (1,723 for skinfolds)
3 9,475 males aged 40 and over

TABLE II

MEAN WEIGHT, MEAN HEIGHT, COEFFICIENT OF REGRESSION (WEIGHT ON HEIGHT), BEST p AND NEAREST INTEGER VALUE FOR p BY BIRTHPLACE AND AGE

Area of Birth	Age at Examination	No. of Subjects	$\overline{W}$ = Intercept Mean Weight (kg)	$\overline{H}$ Mean Height (cm)	b Regression Coefficient (kg/cm)	'Best' p	Nearest Integer No.
Israel	40-49	735	74·3	169·0	0·80	1·82	2
	50-59	538	72·5	165·8	0·66	1·50	2
	60+	157	69·4	163·7	0·47	1·11	1
Eastern Europe ..	40-49	770	71·4	167·1	0·84	1·96	2
	50-59	872	71·3	165·9	0·78	1·81	2
	60+	276	71·0	165·0	0·87	2·02	2
Central Europe ..	40-49	738	73·3	168·9	0·85	1·96	2
	50-59	505	72·4	168·0	0·77	1·78	2
	60+	128	69·3	166·3	0·50	1·20	1
Southeastern Europe ..	40-49	829	73·4	168·9	0·90	2·06	2
	50-59	706	73·5	167·4	0·85	1·93	2
	60+	196	72·5	166·7	0·78	1·79	2
Middle East ..	40-49	1,449	69·1	166·9	0·93	2·24	2
	50-59	749	69·4	165·2	0·81	1·94	2
	60+	169	65·2	162·8	0·91	2·27	2
North Africa ..	40-49	890	72·9	167·9	0·89	2·05	2
	50-59	292	73·7	167·1	0·68	1·55	2
	60+	35	72·3	167·3	0·71	1·64	2
Total		10,034	71·7	167·1	0·83	1·94	2

ethnic groups, that of 50-59 produces values of 1·50-1·94 and that of 60+ produces values of 1·11-2·27.

It is hard to tell whether the variability of estimates is greater with the increase in age, while it does seem that weight-height relationship changes in our population are in such a manner as to produce a higher p in early age (40-49) than in ages 50 and above.

Using Benn's (1971) formula for the standard error of p:

$$SE(p) = \frac{1}{\sqrt{N-3}} \frac{\overline{H}S_W}{\overline{W}S_H} \sqrt{\frac{1 - r^2_{WH}}{1 + r^2_{WH} S^2_W \sqrt{\overline{W}^2}}}$$

we obtain an SE of only 0·03 for the total, values for the SE of 0·09-0·13 for the age 40-49 groups, 0·10-0·20 for the 50-59, and 0·22-0·29 for the 60+ groups. The SE seems to increase with age as a result of a decrease in sample size.

Having found that W/H^2 is the most suitable weight-height index, here follow results using this index.

2. DISTRIBUTION OF W/H^2 BY AGE AND AREA OF BIRTH

Using p = 2, a comprehensive distribution of W/H^2 was calculated for the age-area groups, giving mean and standard deviations as well as values for the 10th, 20th, 50th (median), 80th, and 90th percentiles. As Table III shows, there was a very slight increase with age to the 55-59 age group, followed by a drop in the 60+ age group. Age-adjusted values for the totals of the areas of birth suggest that those born in the Middle East are leaner than the rest of the population. It is difficult to test the significance of this difference, since, for a normally distributed weight and height, the distribution of W/H^2 has not been investigated. However, if we assume W/H^2 to be normal (and the percentile data seem to justify the assumption and have been tested to fit the normal distribution), those born in the Middle East differ significantly from the rest in the mean value of the index ($P < 0·01$).

Similar distributions for weight, height, and an index W/H are included in the 'Physicians' Fact Book' of the study (Medalie *et al.*, 1968), prepared before the superiority of W/H^2 was demonstrated. The weight of examinees returning to the 1965 and 1968 examinations was also recorded, so that

TABLE III

OVERWEIGHT INDEX W/H² BY AREA OF BIRTH AND AGE GROUPS, 1963 AND 1968 (WEIGHT (g) / SQUARED HEIGHT (cm²))*

Area of Birth	No. of Subjects		Average Value**		Standard Deviation		Percentiles***									
	1963	1968	1963	1968	1963	1968	10		20		50		80		90	
Israel ..	1,430	1,281	2·61	2·63	0·35	0·32	2·17	(2·22)	2·34	(2·37)	2·61	(2·64)	2·87	(2·90)	3·02	(3·05)
Eastern Europe	1,918	1,767	2·57	2·61	0·29	0·29	2·21	(2·26)	2·32	(2·38)	2·56	(2·61)	2·80	(2·85)	2·94	(2·99)
Central Europe ..	1,371	1,271	2·55	2·58	0·30	0·28	2·20	(2·22)	2·31	(2·34)	2·56	(2·59)	2·78	(2·81)	2·92	(2·94)
Southeastern Europe ..	1,731	1,597	2·59	2·62	0·31	0·30	2·20	(2·24)	2·34	(2·38)	2·59	(2·62)	2·84	(2·87)	2·98	(3·00)
Middle East ..	2,367	2,200	2·49	2·54	0·36	0·34	2·02	(2·08)	2·19	(2·25)	2·50	(2·55)	2·80	(2·84)	2·95	(2·99)
North Africa	1,217	1,111	2·60	2·64	0·38	0·37	2·11	(2·16)	2·29	(2·33)	2·59	(2·63)	2·90	(2·95)	3·10	(3·13)
Age groups****																
40-44 ..	3,307	3,080	2·54	2·59	0·34	0·32	2·10	(2·18)	2·26	(2·34)	2·55	(2·61)	2·81	(2·86)	2·97	(2·99)
45-49 ..	2,104	1,989	2·55	2·60	0·33	0·32	2·13	(2·17)	2·29	(2·34)	2·56	(2·61)	2·83	(2·87)	2·97	(3·02)
50-54 ..	2,176	2,008	2·58	2·61	0·34	0·31	2·18	(2·21)	2·32	(2·35)	2·58	(2·61)	2·86	(2·87)	3·00	(3·02)
55-59 ..	1,486	1,333	2·59	2·61	0·33	0·31	2·20	(2·23)	2·33	(2·35)	2·58	(2·60)	2·86	(2·88)	3·02	(3·02)
60+ ..	961	817	2·56	2·55	0·33	0·33	2·14	(2·15)	2·30	(2·30)	2·57	(2·56)	2·82	(2·81)	2·97	(2·95)
Total ..	10,034	9,227	2·56	2·60	0·33	0·32	2·14	(2·19)	2·29	(2·34)	2·56	(2·60)	2·83	(2·86)	2·98	(3·01)

* For 1968: 1968 weight (g)/1963 squared height (cm²)
** Age-adjusted by direct method to age distribution of total study population
*** 1968 figures in parentheses
**** 1968 W/H² also given by age as in 1963. Five years should be added to lower and upper bound of each age group to obtain age in 1968, i.e., when weight appearing in 1968 columns was measured.

it was possible to compare the distribution of W/H² five years later. This was done, assuming no change in height (Table III). We are aware that there may be a slight decrease in height toward old age, but since such a decrease is not likely to vary by area of birth, it would have a negligible effect on the results by birthplace. The data are based on 9,227 of the original 10,034 whose weight was retaken in 1968. On the average, the population was 'more obese' (insofar as W/H² does represent obesity), even allowing for aging by five years. The average value of the total population rose from 2·56 in 1963 to 2·60 in 1968, and this was reflected in every age group except the 60+ group which remained stable (Table III). Figure 1 shows the trend in mean W/H² (not tabulated) for age-area groups of three areas—Israel (high values), Central Europe (intermediate values) and the Middle East, excluding Israel (low values), in the first (1963) and the final (1968) examinations of the study.

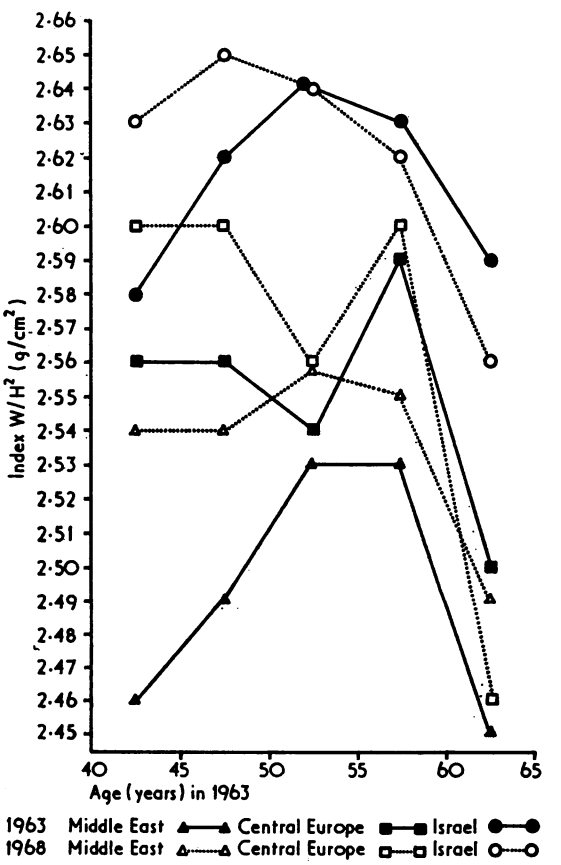

FIG. 1. Mean W/H² (by age in 1963) for three areas of birth, 1963 and 1968.

3. W/H² RELATED TO OCCUPATION, EDUCATION, AND IMMIGRATION.

Tables IV, V, and VI show the mean value and standard deviations of W/H² in the different occupation, education, and immigration categories respectively.

The tabulations for occupation and education provide two similar observations pertaining to correlation between overweight and social status. The groups of workers defined as professionals on the one hand, and labourers on the other, show

TABLE IV

OVERWEIGHT INDEX W/H² BY OCCUPATION AT TIME OF EXAMINATION
WEIGHT (g) / SQUARED HEIGHT (cm²), 1963

Occupational Group	Age 40-49			Age 50-59			Age 60+			Total		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
Administrative and clerical*	3,077	2·57	0·32	1,972	2·61	0·33	465	2·60	0·32	5,514	2·59	0·32
Professional	239	2·52	0·26	273	2·54	0·26	85	2·51	0·24	597	2·53	0·26
Technicians	549	2·55	0·32	367	2·61	0·30	77	2·54	0·34	993	2·57	0·31
Labourers	1,524	2·51	0·37	1,026	2·57	0·38	324	2·53	0·37	2,874	2·53	0·37
Total**	5,389	2·55	0·34	3,638	2·59	0·34	951	2·56	0·33	9,978	2·56	0·33

* Including policemen, prison wardens, nurses
** For 47 subjects the occupation in 1963 was unknown and 9 others could not be classified into any of the above groups.

TABLE V

OVERWEIGHT INDEX W/H² BY DEGREE OF EDUCATION
WEIGHT (g) / SQUARED HEIGHT (cm²), 1963

Degree of Education	Age 40-49			Age 50-59			Age 60+			Total		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
No formal schooling ..	138	2·36	0·39	124	2·48	0·43	42	2·48	0·35	304	2·43	0·40
Partial elementary school..	994	2·51	0·37	617	2·57	0·37	201	2·55	0·38	1,812	2·54	0·38
Complete elementary school (8 yr)	1,142	2·56	0·33	627	2·62	0·34	149	2·59	0·36	1,918	2·58	0·34
Partial high school ..	1,213	2·57	0·33	727	2·60	0·32	174	2·56	0·32	2,114	2·58	0·33
Complete high school (12 yr)	873	2·55	0·31	620	2·63	0·36	139	2·60	0·33	1,632	2·59	0·33
Higher non-university education ..	306	2·57	0·30	228	2·62	0·29	53	2·64	0·28	587	2·60	0·29
Partial university ..	329	2·56	0·29	225	2·55	0·29	55	2·55	0·33	609	2·56	0·29
Completed university ..	400	2·56	0·27	478	2·55	0·27	144	2·53	0·26	1,022	2·55	0·27
Total*	5,395	2·55	0·34	3,646	2·59	0·34	957	2·56	0·33	9,998	2·56	0·33

* The education of 36 subjects is unknown.

TABLE VI

OVERWEIGHT INDEX W/H² BY YEAR OF IMMIGRATION TO ISRAEL
WEIGHT (g) / SQUARED HEIGHT (cm²), 1963

Period of Immigration	Age 40-49			Age 50-59			Age 60+			Total		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
1932 or earlier	354	2·59	0·33	495	2·59	0·34	236	2·54	0·34	1,085	2·58	0·34
1933-38	699	2·53	0·31	802	2·57	0·32	160	2·54	0·34	1,661	2·55	0·32
1939-47	886	2·53	0·33	339	2·55	0·30	72	2·49	0·32	1,297	2·53	0·32
1948-52	2,491	2·54	0·34	1,390	2·60	0·34	328	2·59	0·31	4,209	2·56	0·34
1953-62	246	2·53	0·33	98	2·59	0·33	8	2·60	0·30	352	2·55	0·33
Born in Israel	735	2·60	0·34	538	2·64	0·37	157	2·59	0·37	1,430	2·61	0·35
Total	5,411	2·55	0·34	3,662	2·59	0·34	961	2·56	0·33	10,034	2·56	0·33

the lowest value of W/H². In the education sphere the no-schooling group reveals a striking degree of underweight (in reference to the average, not necessarily to the desirable weight) and those with university education tend to be 'leaner' at ages 50 and over. All the differences mentioned are significant at the 0·01 level at least.

Table VI reveals an interesting pattern: the Israeli-born have the highest mean W/H² in all the age groups while the immigrants who arrived in 1939-47 have consistently the lowest values. The latter group consists mainly of European Jews who survived and escaped from the horrors of the second world war and the concentration camps.

4. W/H² AND PHYSICAL ACTIVITY

In the second examination of our study (1965) two questions related to physical activity at work

TABLE VII

OVERWEIGHT INDEX W/H² BY DEGREE OF SELF-REPORTED PHYSICAL ACTIVITY
WEIGHT (g), 1965 / SQUARED HEIGHT (cm²), 1963

Degree of Activity	Age 40-49*			Age 50-59*			Age 60+*			Total		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
1. Least activity** ..	1,214	2·59	0·32	1,209	2·60	0·31	486	2·59	0·32	2,909	2·59	0·31
2. Little or no activity ..	1,408	2·60	0·32	1,307	2·61	0·31	519	2·59	0·32	3,234	2·60	0·32
3. Moderate activity ..	2,561	2·57	0·34	2,360	2·59	0·33	769	2·57	0·33	5,690	2·58	0·33
4. Much activity ..	354	2·53	0·36	236	2·59	0·35	53	2·56	0·34	643	2·56	0·35
5. Most active*** ..	90	2·57	0·33	54	2·49	0·39	10	2·54	0·40	154	2·54	0·36
Total****	4,323	2·58	0·34	3,903	2·60	0·33	1,341	2·58	0·33	9,567	2·59	0·33

* Age in 1965
** Included in 2
*** Included in 4
**** The physical activity of 46 subjects was not recorded; 348 subjects had died since 1963 or did not report for the 1965 examination. For 98 others the 1965 weight was not recorded.

TABLE VIII

OVERWEIGHT INDEX W/H² BY CURRENT SMOKING HABITS AND AGE
WEIGHT (g) / SQUARED HEIGHT (cm²), 1963

Smoking Habits	Age 40-49			Age 50-59			Age 60+			Total		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
≤ 10 cigarettes/day ..	802	2·56	0·33	539	2·63	0·39	150	2·56	0·33	1,491	2·59	0·35
11-20 cigarettes/day ..	913	2·49	0·35	577	2·53	0·33	139	2·52	0·37	1,629	2·51	0·35
> 20 cigarettes/day ..	1,205	2·50	0·35	616	2·54	0·34	121	2·50	0·35	1,942	2·51	0·35
Cigar or pipe only ..	61	2·57	0·34	61	2·65	0·33	19	2·52	0·32	141	2·59	0·29
Ex-smokers	728	2·59	0·32	712	2·61	0·30	232	2·60	0·32	1,672	2·60	0·31
Never smoked ..	1,697	2·58	0·31	1,155	2·62	0·32	300	2·58	0·32	3,152	2·59	0·31
Total*	5,406	2·55	0·33	3,660	2·58	0·34	961	2·56	0·34	10,027	2·56	0·33

* Smoking habits of seven subjects were not recorded.

TABLE IX

OVERWEIGHT INDEX W/H² BY PAST SMOKING HABITS AND TIME STOPPED SMOKING, 1965

When Stopped	Previous Smoking Habits (Cigarettes)									Total Ex-cig. Smokers			Cigar or Pipe only			Total		
	1-10			11-20			> 20											
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
In past 2 years ..	123	2·66	0·33	196	2·62	0·30	171	2·68	0·31	490	2·65	0·31	10	(2·62)	(0·28)	500	2·65	0·31
2-5 years ago	62	2·58	0·29	131	2·60	0·30	149	2·67	0·32	342	2·63	0·31	5	(2·36)	(0·43)	347	2·62	0·31
Over 5 years ago ..	194	2·57	0·29	330	2·59	0·30	409	2·63	0·31	933	2·61	0·30	16	2·56	0·36	949	2·61	0·30
All ex-smokers	379	2·60	0·30	657	2·60	0·30	729	2·65	0·31	1,765	2·62	0·31	31	2·54	0·38	1,796		
Never smoked																3,063	2·61	0·31
Smoking now																4,604	2·56	0·34

Figures based on 10 subjects or less are given in parentheses. Forty-four 'conflicting' answers are excluded. These include 41 reporting only previous smoking habits in one question as well as present smoking in the other question; three others reported smoking now as well as having stopped smoking.

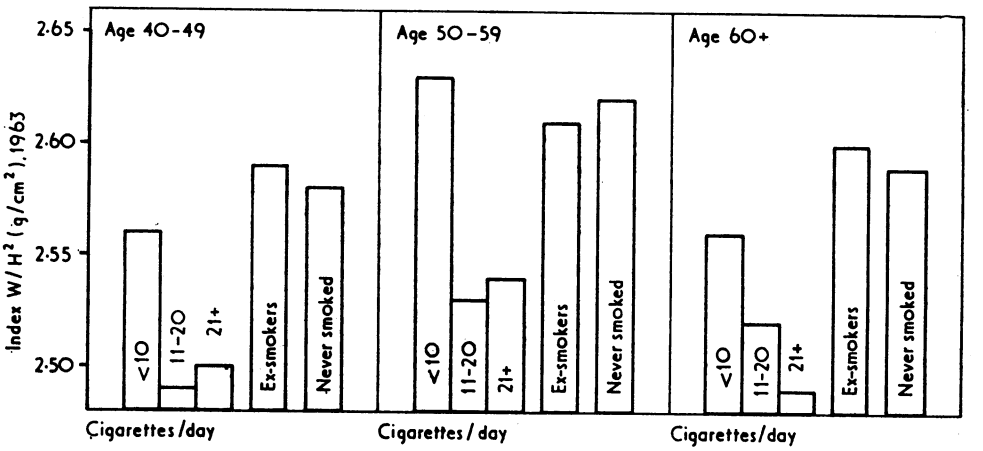

FIG. 2. W/H² of current cigarette smokers by amount smoked.

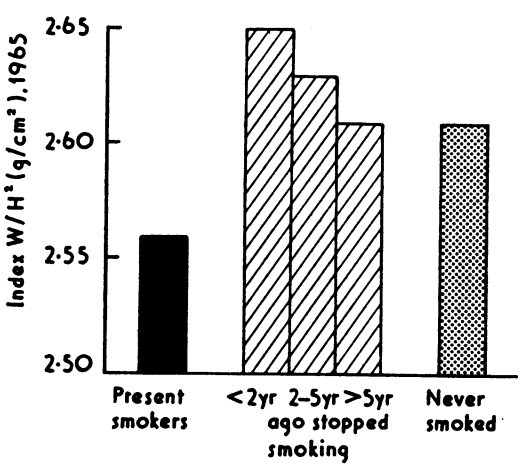

FIG. 3. W/H² by time lapsed since smoking was stopped.

and outside work were included. From the answers a classification of these activity categories was constructed. Mean values and standard deviations of 1965 weight divided by 1963 squared height are given in Table VII for these categories (for details of the questions and definitions of categories, see Appendix).

The small 'most active' group (154 men) has mean values significantly lower than the others from the age of 50 and over ($P < 0{\cdot}01$). There are no other noticeable differences.

5. W/H² AND SMOKING

Table VIII and Fig. 2 give W/H² by current smoking habits (1963) and age. Smokers of more than 10 cigarettes per day have significantly lower values ($P < 0{\cdot}001$) than non-smokers in all three

TABLE X

OVERWEIGHT INDEX W/H² BY SELF-REPORTED PHYSICAL ACTIVITY AND CURRENT SMOKING HABITS
WEIGHT (g) / SQUARED HEIGHT (cm²), 1965

Degree of Activity	Smoking Habits																	
	1-10 Cigarettes per Day			11-20 Cigarettes per Day			> 20 Cigarettes per Day			Cigar or Pipe only			Never Smoked			Ex-smokers		
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
1. Least* ..	376	2·61	0·33	519	2·53	0·33	375	2·57	0·33	83	2·66	0·29	921	2·60	0·31	582	2·63	0·29
2. Little ..	401	2·61	0·33	590	2·54	0·33	444	2·57	0·34	86	2·67	0·30	973	2·61	0·31	639	2·64	0·29
3. Moderate	824	2·59	0·33	1,133	2·52	0·35	726	2·54	0·35	109	2·61	0·31	1,842	2·61	0·31	1,025	2·62	0·31
4. Much ..	70	2·58	0·35	131	2·47	0·33	86	2·45	0·39	13	2·63	0·39	220	2·63	0·34	125	2·58	0·33
5. Most**	17	2·62	0·40	40	2·52	0·29	22	2·55	0·47	2	1·92	0·38	45	2·53	0·36	33	2·60	0·30
Total*** ..	1,295	2·60	0·33	1,854	2·52	0·34	1,256	2·55	0·35	208	2·64	0·32	3,035	2·61	0·31	1,789	2·62	0·31

* Included in 2
** Included in 4
*** 348 died since 1963 or did not report for the 1965 examination; 274 had either physical activity, smoking habits, or weight not recorded.

age groups. Smokers of 10 cigarettes or less, ex-smokers, cigar and pipe smokers, and those who had never smoked were all on a similar level.

Table IX and Fig. 3 show some additional interesting features in that the weight-height index of the ex-smokers seems to rise sharply and then decrease as the length of time increases since the cessation of smoking. Subjects who had stopped smoking within the previous two years had a W/H^2 index of 2·65, as compared to 2·63 and 2·61 for those who had stopped two to five years before and more than five years before. The latter group reach the W/H^2 figure of those who had never smoked (2·61), remaining higher (heavier), however, than the present smokers (2·56).

The hypothesis of no slope of W/H^2 over the periods since smoking was stopped (assigning them scores of 1, 3½, and 5) was rejected at $P = 0{\cdot}05$ ($t_{(2)} = -4{\cdot}4$), i.e., that trend is significant.

It is also worthy of note that the heaviest ex-smokers (20 or more cigarettes per day) have the highest W/H^2 index in all time periods.

6. W/H^2, Smoking and Physical Activity

The main points emerging from Table X are:

(a) There is a strong decrease in W/H^2 ($P < 0{\cdot}01$)* in all categories of physical activity from the 1-10 cigarettes/day group to the 11-20 cigarettes/day group. However, the latter does not show noticeable differences from the group of 'heavy smoking' (20 cigarettes/day or more). None of the latter differences is significant and they are not all in the same direction.

(b) There is a pattern of a decrease in W/H^2 index, with increase in physical activity for present smokers (especially the heavier smokers) and ex-smokers, but no such pattern for those who had never smoked.

7. W/H^2 and Diet

Information about dietary habits was collected in 1963 (Balogh, Medalie, Smith, and Groen, 1968) and the correlation coefficient between W/H^2 and each of 13 dietary variables was calculated. In all three age groups, the largest departure from zero was −0·19 (saturated fat in the 50-59 age group) and most values were very close to zero. It was concluded that there was no correlation between dietary variables as estimated in this study and the the W/H^2 index.

* For the 'little' and 'moderate' activity groups, $P < 0{\cdot}001$

Discussion

Numerous investigators have attempted to find a suitable weight-height index for their specific purposes. Mainly tested were indices of the form W/H^p (integer p). Billewicz, Kemsley, and Thomson (1962), Khosla and Lowe (1967), Florey (1970), Benn (1971), Keys *et al.* (1972), and others used different sets of data and have all demonstrated that setting $p = 2$ resulted in minimum correlation with height. Benn (1971) demonstrated an equivalence between a W/H^p type index and relative weight under first approximation (Taylor series expansion). He also showed that the maximum correlation between a measure of relative adiposity, which is uncorrelated with height, and a W/H^p index is obtained by using the same p† that would yield an index equivalent to that relative weight.

The male population in our study supplies further confirmation that W/H^p is the best power-type index with integer power (based on principles suggested and discussed by the aforementioned authors). In addition to its lowest correlation with height (as compared to other W/H^p indices), the matrix of correlations among the previously suggested indices for overweight is very similar to that calculated from the Framingham and Birmingham data.

Several workers have examined the patterns of Quetelet index (W/H^2) as associated with age, occupation, education, period of immigration, physical activity, and smoking habits. Comparisons with some of these studies are difficult and must be accepted with caution owing to some differences in the technique of examinations, etc. Several of our findings are in good agreement with those of Bjelke (1971) in the population of Norway, although the consistent rise of W/H^2 with age in Norway was not found in our study. In Israel, above the age of 50 the index rose only slightly, and above 60 it dropped a little. It must be noted, however, that the Norwegian data were collected by a questionnaire and not by direct measurement. It is also important to note the great difference, in that period (1963-64) at least, in mean height between the Norwegian sample (176·9 cm for ages 37-64) and the Israeli one (166·7 cm when age-adjusted to the age structure of the Norwegian population, except ages 40-44 which are substituted for 37-44). This difference is very large compared with possible differences arising from non-identical measurement methods. The findings of Khosla and Lowe (1968) among 18,000 Welsh steel workers are similar to

† $\frac{\bar{H}S_W}{\bar{W}S_H} r_{WH}$ where S_W and S_H are the standard deviations of weight and height and r_{WH} the correlation between them.

ours in respect of association with age. Both the above studies use cross-sectional data only, whereas we have been able to add the results and changes of longitudinal (five-year) observations.

In respect of the association with occupation/education, we confirmed the Norwegian findings of low W/H^2 values for professionals. In addition, however, we found low values for the 'never-studied' (or least educated) group.

The period of immigration and the actual fact of immigration, rather than length of stay in the country, proved to be related to W/H^2 in our Israeli population, in which the Israeli-born had consistently higher values in all categories. Among the immigrants, those who immigrated in the period of the second world war, or immediately afterwards, had low values. Concentration camps and ghetto and partisan activities experienced by this group of immigrants may be associated with this finding.

Our finding on the dependency of W/H^2 on the degree of current cigarette smoking is a strong confirmation of several other investigations (Ashford *et al.*, 1961; Natvig and Vellar, 1965; Bjelke, 1971; Khosla and Lowe, 1971, 1972). The only study with little association found between smoking and body weight was that by Waller and Brooks (1972), but their sample was one of people visiting a public health exhibition—hardly a group representing all classes, or all properties related to obesity and non-smoking.

Smokers of more than 10 cigarettes per day exhibit, in this study, a pronounced decrease in mean W/H^2—2·51 as compared to 2·59-2·60 for all other groups, whether non-smokers, ex-smokers, light cigarette smokers, or cigar and pipe smokers. Bjelke (1971) found mean values of 2·50 for men aged 45-64 smoking 10 cigarettes or more per day as compared to 2·54-2·56 for the other groups (the one slight deviation being a value of 2·49 for light smokers aged 45-54).

Our findings in this respect were different from those of Khosla and Lowe (1971) in that ours were independent of age whereas theirs were associated.

In summary, it appears that smoking is associated with a decreased W/H^2 index, the effect becoming marked when 10 or more cigarettes per day are consumed. A number of interesting points arise in connection with ex-smokers. The group of people who gave up smoking within the two years previous to the examination were considerably heavier than the 'never smoked' or the 'smokers'. Those, however, who had smoked up to one pack ($\leq$ 20) of cigarettes per day 'returned' to the weight-height index of the 'never smoked' fairly quickly, whereas those who had smoked 21 or more cigarettes per day did not return to the 'never smoked' level even five and more years later.

These results suggest that once smokers stop smoking they tend to gain weight fairly rapidly and then gradually return to the level of the 'never smoked' but not to the level of the 'smokers'. If this were true (as only a follow-up of ex-smokers could prove), it would have meaningful implications in clinical and public health practice. Our results in this respect are in disagreement with those of Khosla and Lowe (1971). They found ex-smokers of the same ages to be heavier than smokers but not as heavy as those who had never smoked. Their findings also indicate a gradual rise of W/H^2 for ex-smokers as time elapses rather than a sharp rise and then a decrease. Some of these differences may be due to the differences between the cohorts, or to differences in behaviour of the Welsh steel workers and Israeli civil employees, but the universal finding seems to be that ex-smokers tend to gain weight after they stop smoking. A crucial point is that both analyses were cross-sectional ones, of different cohorts. A follow-up of men who have stopped smoking is needed to establish accurately the effect of cessation of smoking on W/H^2.

Our definition of physical activity categories, based on self-reported activity, produced marked differences in W/H^2 for smokers (especially of more than 10 cigarettes per day) where a decrease of W/H^2 with rise of self-reported activity is observed. This is apparently logical in that the marked effect of smoking on reducing the index is added to that of physical activity. The latter also affects, to a much smaller degree, the index of ex-smokers in the same direction, i.e., a slight decrease in index with increase in activity. It is, however, strange that the weight of those who do not smoke and have never smoked showed no effect of increased physical activity (the reduction of the index among the 'never smoked' in the highest physical activity category is non-significant and is based on small numbers). It might be speculated that non-smokers need far more physical activity than smokers to reduce their weight. With all the limitations, however, of a study involving many variables and a particular segment of the Israeli population, this remains a lead for more specific investigation.

Finally, overweight was not found to be associated with the subject's usual diet (as we measured it). At this stage we have no hypothesis about the validity or significance of this finding, considering the well-known difficulties in measuring dietary habits in large-scale epidemiological studies.

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Appendix overleaf

Appendix

Definition of 'Physical Activity' Categories

The following two questions were included in the 1965 questionnaire of the study:

Question	Possible Answers
How would you define your physical activity in connection with your work?	Mainly sitting .. 1 Mainly sitting behind a wheel .. 2 Mainly standing .. 3 Mainly walking .. 4 Mainly physical labour .. 5 Not working .. 6 Physical labour of some other kind 7
What is your physical activity outside working hours (e.g., riding a bicycle or walking to work and back, etc.)?	Almost no daily physical activity.. 1 Light to moderate activity, but not daily (e.g., weekends and holidays only) .. .. 2 Light daily physical activity such as a walk of 3 km .. 3 Moderate to heavy daily physical activity (swimming, gardening, etc.) .. 4

Answers were then combined to give the categories I ('least' activity), II ('little' activity), III ('moderate' activity), IV ('much' activity), and V ('most' activity) as follows:

Activity at Work	Activity outside Work				
	1	2	3	4	No Answer
1 ..	I & II	I & II	III	III	II
2 ..	II	II	III	III	II
3 ..	III	III	III	IV	III
4 ..	III	III	III	IV	III
5 ..	III	IV	IV & V	IV & V	IV
6 ..	I & II	I & II	III	IV	II
7 ..	III	IV	IV & V	IV & V	IV
No answer	II	II	III	IV	Unknown