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Physical Characteristics of Yemenite and Kurdish Jews in Israel

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III. Physical characteristics of Yemenite and Kurdish Jews in Israel

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The body measurements and skin colour of samples of Israeli Jews aged 20 to 30, born in the Yemen and in Kurdistan, are reported.

The Jews from Kurdistan ('Kurdish Jews') were significantly larger than the Jews from the Yemen ('Yemenite Jews') in the majority of body dimensions. The groups differed more in transverse than in longitudinal measurements; there were small differences between them in skeletal shape.

The Kurdish Jews were heavier than the Yemenite Jews; an appreciable number of individuals (particularly among the Kurdish females) were 'overweight' by British or American standards for height and age. Excess mass among the Kurdish Jewish women appeared to be largely due to fat, but among the men was probably due to muscle.

The Yemenite Jews were darker skinned than the Kurdish Jews, but not as dark as Africans. The Kurdish Jews were darker than Europeans, and both groups had similar reflectance curves to other populations in southwest Asia.

These results are discussed in relation to the genetic, nutritional, and occupational circumstances of the samples.

Introduction

Comparatively little is known of the body dimensions of the people of southwest Asia. Numerous reports by physical anthropologists in the past (e.g. Field 1939, 1951, 1952, 1956; Seltzer 1936, 1940; Shanklin 1935) have included height, sometimes sitting height, and a large battery of head measurements. Mass, and the size and shape of the remainder of the body, however, have usually been neglected.

Although a number of Jewish populations in southwest Asia have been studied (Weissenberg 1909; Field 1953), no comprehensive anthropometric survey has yet been carried out in Israel. A large number of genetically distinct Jewish groups have recently come together in Israel, often to live side by side under very similar conditions. This situation provides the human biologist with an excellent opportunity to record the physical characteristics of such groups, and to attempt to relate these to, for example, their past and present climatic, nutritional, and occupational conditions. Such studies are directly relevant to the aims of the Human Adaptability Section of the International Biological Programme (Baker & Weiner 1966).

The heights and masses of small selected samples of the Israeli population have been recorded (Brunner & Lobl 1958; Cohen, Bavly & Poznansky 1961; Zaizov & Laron 1966), and Lippert (1965) reported on a survey of the height, mass, and sitting height of 10000 Israeli males of various origins, aged 40 and over. However, no detailed record of the anthropometry of a well-defined group of Jewish immigrants has yet been made.

Since the introduction of portable reflectance spectrophotometers for the measurement of skin colour (see Weiner 1951) a number of surveys have been carried out on various populations throughout the world (Lasker 1954; Barnicot 1958; Weiner *et al.* 1964; Huizinga 1965;

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Harrison *et al.* 1969). The only published study of an Israeli population is that of Hulse (1971), who measured the skin colour of a sample of Jews from Habban, in South Arabia, now settled in Israel. Sunderland (1967) has measured the skin colour of several groups of various origins in Azraq, eastern Jordan.

Subjects and methods

The subjects of this study were Jews aged 20 to 30, born in the Yemen and in Kurdistan, who had immigrated to Israel in 1950–52. They lived in five settlements in the northern Negev (in the southern part of Israel), near the town of Beer Sheva (Edholm & Samueloff 1973; Bavly 1973). The anthropometric study sample included 97 Jews from Kurdistan ('Kurdish Jews') and 72 Jews from the Yemen ('Yemenite Jews') of both sexes, representing approximately 75 % of the total population of the five villages in this age group. Those who did not participate were either absent at the time of the survey (e.g. on Army training), were unwilling to participate, or were incapacitated (for details see Edholm & Samueloff 1973, this volume).

The body measurements were carried out as described in the *I.B.P. Handbook* (Weiner & Lourie 1969). Subjects were weighed on a portable scale with non-detachable weights (Herbert & Sons Ltd). Height and mass were measured without shoes, and all measurements were taken with the subjects wearing only light clothing, or, wherever convenient, partially unclothed. Representative samples of clothing were weighed, and an allowance made in the analysis for the amount worn at the time of the measurement. The masses are thus intended to represent nude weights. The masses of women beyond the first trimester of pregnancy were excluded from the analysis. The mass of each subject was taken as the average of masses recorded in the summer and winter (see below).

Lean body mass was calculated (in males only) by subtracting an estimate of fat mass from body mass: fat mass was calculated as a percentage of body mass by the formula of Durnin & Rahaman (1967):

$$\text{body fat (\%)} = 100 \times \left(\frac{4.95}{1.161 - 0.0632 \lg x} - 4.5 \right),$$

where x is the sum of skinfold thicknesses at biceps, triceps, subscapular and suprailiac sites.

The ponderal index was calculated for each subject as height (cm)/$\sqrt[3]{}$ mass (kg). Surface area was calculated according to a nomogram based on the height–mass formula of DuBois & DuBois (1916).

Skin colour was measured on the medial surface of the left upper arm, several minutes after washing the site with warm soapy water. The instrument used was the E.E.L. reflectance spectrophotometer model 99 (Evans Electroselenium Ltd), which has been used in the majority of recent field surveys. Readings were taken of the percentage reflectance (compared to the makers' magnesium carbonate white standard) at three wavelengths of incident light: 425 nm (filter no. 601 in the photometer head); 545 nm (filter 605); and 685 nm (filter 609).

The measurements were made by the author and two assistants during June and July 1968, and were carried out during the late afternoon and evening, usually in the village clinic. Subjects were also reweighed during a second period of field work in January and February 1969. Repeat measurements were made on a number of subjects to assess the comparability of the readings obtained by the three anthropometrists. Errors were found to be random and within acceptable limits (± 2 to 3 %).

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Results

Body measurements

The means and standard deviations of the body measurements are presented in tables 1 and 2. Mass, lean body mass, surface area and ponderal index are given in table 3. The means and standard deviations of the skinfold thicknesses at biceps, triceps, subscapular and suprailiac sites in males, and biceps and triceps sites in females, are given in table 4.

Table 1. Body measurements (cm) of males

	Kurdish Jews			significance of difference	Yemenite Jews		
dimension, index	*n*	mean	s.d.		*n*	mean	s.d.
height	56	167.56	5.60	***	34	162.58	4.87
sitting height	55	89.55	3.02	**	33	86.95	2.85
height of ant. sup. il. spine	55	98.66	4.71	**	33	95.53	4.10
bi-acromial diameter	54	39.48	2.08	***	33	37.77	1.64
bi-iliac diameter	55	27.56	1.64	***	33	25.42	1.19
transverse chest	54	27.46	2.12	**	33	26.12	1.65
ant. post. chest	54	20.14	1.73	***	33	18.32	1.54
chest circumference	53	93.26	6.29	*	33	89.85	7.42
total arm length	55	75.78	3.23	***	33	73.26	3.38
upper arm circumference	55	28.05	2.13	n.s.	33	27.08	2.79
calf circumference	55	35.33	3.01	*	33	34.00	2.81
bicondylar femur diameter	55	9.20	0.49	**	31	8.84	0.59
wrist breadth	55	5.82	0.34	***	33	5.52	0.24
hand breadth	55	8.14	0.45	***	33	7.66	0.52
ankle breadth	55	7.40	0.39	***	33	6.97	0.34
foot length	54	24.99	1.19	***	33	23.99	1.29
head length	55	17.67	0.94	n.s.	33	17.45	0.60
head breadth	55	14.94	0.79	***	33	13.78	0.55
nose height	55	5.63	0.43	**	33	5.36	0.35
nose breadth	55	3.71	0.32	n.s.	32	3.66	0.24
total face height	55	12.67	0.57	***	33	12.05	0.65
bizygomatic diameter	55	12.06	0.67	***	33	11.45	0.55
relative sitting height	55	53.46	1.14	n.s.	33	53.44	1.13
cephalic index	55	84.56	4.21	***	33	79.05	4.06
nasal index	55	66.24	6.90	n.s.	32	68.45	5.94

n.s. (not significant) $P > 0.05$. * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$.

In both sexes, the Kurdish Jews exceeded the Yemenite Jews in the majority of body dimensions. Most of these differences were statistically highly significant. There was, for example, a highly significant difference in height between the two groups of males. This was due both to a difference in leg length (height of iliac spine) and in trunk length (sitting height), hence their relative sitting heights (sitting height as a percentage of stature) were almost identical.

The female Kurdish Jews, however, were on average only 0.6 cm taller than the female Yemenite Jews, who had a shorter trunk but slightly longer legs. Relative sitting height in the female Kurdish Jews was thus greater than in the female Yemenite Jews. Total arm length and foot length, which are both highly correlated with stature, showed larger differences between the males than between the females.

With the exception of sitting height, body lengths – i.e. dimensions parallel with the long axis of the body – thus differentiated the males of the two groups, but not the females. Dimensions perpendicular to the long axis, however, such as shoulder and hip breadths, and chest

Table 2. Body measurements (cm) of females

dimension, index	Kurdish Jews n	Kurdish Jews mean	Kurdish Jews s.d.	significance of difference	Yemenite Jews n	Yemenite Jews mean	Yemenite Jews s.d.
height	41	152.61	4.34	n.s.	38	151.98	5.79
sitting height	41	82.33	2.26	**	36	80.24	3.13
height of ant. sup. il. spine	40	89.03	4.12	n.s.	36	89.11	4.34
bi-acromial diameter	40	34.53	2.12	n.s.	38	33.49	2.12
bi-iliac diameter	40	27.72	2.44	**	34	25.77	2.52
transverse chest	39	24.63	2.23	*	33	23.52	1.66
ant. post. chest	40	18.51	1.80	**	37	17.23	1.44
total arm length	41	68.29	2.73	n.s.	38	67.99	3.65
upper arm circumference	40	27.78	4.46	***	38	24.36	3.32
calf circumference	39	35.05	3.53	**	34	32.71	3.45
bicondylar femur diameter	41	8.54	0.68	***	38	7.84	0.73
wrist breadth	40	5.37	0.43	***	37	5.05	0.33
hand breadth	40	7.81	0.62	**	37	7.40	0.47
ankle breadth	41	6.68	0.63	***	38	6.20	0.41
foot length	41	22.19	1.16	n.s.	37	21.97	1.27
head length	40	16.74	0.67	***	38	17.34	0.69
head breadth	41	14.42	0.60	***	38	13.77	0.61
nose height	41	5.33	0.45	*	38	5.11	0.47
nose breadth	41	3.21	0.24	n.s.	38	3.29	0.21
total face height	41	11.70	0.72	***	38	10.94	0.59
bizygomatic diameter	41	11.87	0.79	**	38	11.40	0.63
relative sitting height	41	53.97	1.17	***	36	52.80	1.36
cephalic index	40	86.20	4.51	***	38	79.50	4.41
nasal index	41	60.65	5.91	**	38	64.88	6.42

n.s. (not significant) $P > 0.05$. * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$.

breadth and depth, showed significant group differences in both sexes. Within each sex, these body breadths showed a larger intergroup difference than did the body lengths: leg length, arm length, sitting height and foot length. The bony widths at knee, wrist, hand and ankle also differed more between the Kurdish and the Yemenite Jews than did the length measurements.

Skinfold thickness was slightly greater in male Yemenite Jews than in male Kurdish Jews, but the female Kurdish Jews had much thicker skinfolds than the female Yemenite Jews. In both sexes limb circumferences were larger in the Kurdish Jews, the differences being greater between the females than between the males. The Kurdish Jews were also significantly heavier than the Yemenite Jews in both sexes, and among the males there was an even larger difference between the groups in lean body mass. Surface area was significantly greater in the Kurdish Jews of both sexes. The ponderal index did not distinguish the males of the two groups, but the female Kurdish Jews had a significantly lower mean value than the female Yemenite Jews, indicating a larger overall body mass.

The cephalic index of the males was about $5\frac{1}{2}$ percentage points, and that of the females about $6\frac{1}{2}$ points, more in the Kurdish than in the Yemenite Jews. Among the men, the Kurdish Jews had broader heads than the Yemenite Jews, but there was less difference in head length. The female Kurdish Jews had longer as well as broader heads than the female Yemenite Jews.

The Yemenite Jews had relatively broader noses than the Kurdish Jews (i.e. a higher nasal index), due to the greater nose height of the latter, rather than to an absolute difference in breadth between the groups. The Kurdish Jews of both sexes also had longer and broader faces than the Yemenite Jews.

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TABLE 3. MASS, LEAN BODY MASS, PONDERAL INDEX AND SURFACE AREA

	males							females						
	Kurdish Jews			significance of difference	Yemenite Jews			Kurdish Jews			significance of difference	Yemenite Jews		
	n	mean	s.d.		*n*	mean	s.d.	*n*	mean	s.d.		*n*	mean	s.d.
mass/kg	56	65.99	8.8	*	33	61.69	9.57	41	59.68	13.12	**	38	51.13	8.99
lean body mass/kg	50	49.17	7.98	**	29	43.75	8.06	—	—	—		—	—	—
ponderal index/cm $kg^{-\frac{1}{3}}$	56	41.58	1.54	n.s.	33	41.37	2.08	41	39.41	2.48	**	37	41.00	2.25
surface area/m^2	56	1.743	0.125	**	33	1.657	0.125	41	1.556	0.161	**	36	1.464	0.126

n.s. (not significant) $P > 0.05$. * $P < 0.05$. ** $P < 0.01$.

TABLE 4. SKINFOLD THICKNESSES

	males							females						
	Kurdish Jews			significance of difference	Yemenite Jews			Kurdish Jews			significance of difference	Yemenite Jews		
	n	mean	s.d.		*n*	mean	s.d.	*n*	mean	s.d.		*n*	mean	s.d.
triceps/mm	50	6.42	2.28	*	30	7.84	3.60	14	14.22	7.89	n.s.	8	8.81	5.45
biceps/mm	50	3.78	0.97	n.s.	30	4.07	1.46	17	7.84	4.46	n.s.	8	4.45	2.18
subscapular/mm	51	10.72	4.57	n.s.	29	11.11	4.51	—	—	—		—	—	—
suprailiac/mm	47	12.60	5.88	n.s.	24	14.02	7.75	—	—	—		—	—	—

n.s. (not significant) $P > 0.05$. * $P < 0.05$.

Skin colour

The percentage skin reflectance values at three wavelengths of males and females in the two groups are given in table 5. In all cases the reflectance values were higher at the longer wavelengths. At each wavelength the Yemenite Jews had a lower reflectance (i.e. were darker skinned) than the Kurdish Jews in both sexes, and within each group males were darker than females. The sex difference was highly significant ($P < 0.001$) in both groups at all wavelengths.

TABLE 5. SKIN COLOUR REFLECTANCE VALUES

	filters											
	601 (425 nm)				605 (545 nm)				609 (685 nm)			
	n	mean	s.d.	c.v.	*n*	mean	s.d.	c.v.	*n*	mean	s.d.	c.v.
males:												
Kurdish Jews	52	21.11	4.21	19.9	52	29.19	5.32	18.2	52	54.89	5.88	10.7
Yemenite Jews	33	18.36	2.25	12.3	33	26.50	2.67	10.4	32	53.15	2.81	5.3
significance of difference		***				**				n.s.		
females:												
Kurdish Jews	39	24.19	3.53	14.6	39	33.73	3.52	10.4	39	60.02	3.10	5.2
Yemenite Jews	38	21.61	4.77	22.1	38	31.36	4.86	15.5	38	56.94	4.84	8.5
significance of difference		**				**				***		

s.d.: standard deviation. c.v.: coefficient of variation. n.s. (not significant), $P > 0.05$. **, $P < 0.01$. ***, $P < 0.001$.

The variability of the reflectance values in each group, expressed as the coefficient of variation, decreased progressively from the short to the long wavelengths.

Interpopulation comparisons of skin reflectance values may differ in both sign and magnitude according to the wavelength at which the measurements are made. A log transformation of the reflectance at 425 nm and antilog transformation at 685 nm have been shown to make the relative positions of different populations more comparable at these two wavelengths (Harrison & Owen 1964). The means and standard deviations of these transformed reflectance values are given in table 6.

TABLE 6. TRANSFORMED SKIN COLOUR REFLECTANCE VALUES

	$\log_{10}$ (425 nm reading)			antilog (685 nm reading)		
	n	mean	s.d.	*n*	mean	s.d.
male Kurdish Jews	52	1.313	0.086	52	0.361	0.037
male Yemenite Jews	33	1.260	0.055	32	0.341	0.022
female Kurdish Jews	39	1.379	0.064	39	0.393	0.052
female Yemenite Jews	38	1.325	0.089	38	0.375	0.042

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Discussion

Body measurements

Godber *et al.* (1973, this volume) have shown that the Kurdish and Yemenite Jews in this survey were genetically markedly dissimilar. They point out that the Yemenite Jews must have interbred considerably with Arab and also African populations, whereas the Kurdish Jews remained more isolated from their neighbours. The subjects of this survey are living today in virtually identical climatic and social conditions, in villages within a few miles of each other.

The anthropometric differences between the two groups have to be considered in terms of possible environmental and genetic factors. There is some difference in occupational structure between the two groups (Edholm & Samueloff 1973); the most important difference between them in environmental conditions, however, is in relation to their past and present levels of nutrition. The Jews in the Yemen appear to have been in a worse nutritional state than the Jews in Kurdistan (Semach 1910; Fischel 1944; Goitein 1947; Roth 1953; Ben-Zvi 1958). On their arrival in Israel, the Yemenite Jews were observed to be malnourished in comparison with the Kurdish Jews (S. Samueloff, personal communication). At present, both groups have average calorie intakes in excess of the U.N. recommended dietary allowances, the Kurdish Jews consuming considerably more than the Yemenite Jews (Bavly 1973).

Animal experiments indicate that nutritional deprivation in early life is likely to result in failure to attain full adult stature (McCance 1962, 1968). There is considerable circumstantial evidence from human studies that malnutrition in childhood may have a similar effect (Hiernaux 1965; Graham 1968; Thomson 1968). It is therefore possible that some of the difference in stature between the Kurdish and Yemenite Jews may be due to the poorer nutrition of the Jews in the Yemen.

There is a tendency for the younger subjects in the present sample (i.e. those who left the Yemen or Kurdistan at an early age) to be taller than the older subjects. These differences are small, but are greater among the Yemenite than among the Kurdish Jews. This would be consistent with an exposure to a lower level of nutrition in the Yemen than in Kurdistan. The differences are also larger in the females than in the males. It is well recognized that girls are better able than boys to 'catch-up' and return to their original growth curves when recovering from periods of diminished food intake (Tanner 1962).

Attempts have been made in a number of anthropometric studies to distinguish those body dimensions which are mainly under genetic control, and those chiefly influenced by the environment. Osborne & de George (1959), in their twin study, showed that the heritability of height, sitting height, and arm, leg and foot lengths was greater than that of body breadths and bony diameters. Lower still was the heritability of mass, limb circumferences, and skinfolds. A stronger genetic control of longitudinal than transverse skeletal measurements was also found in the twin studies of Clark (1956), Takkunen (1964), and Vandenberg & Strandskov (1964), and in Howells' correlations of siblings (1966). A similar pattern was found in the migrant studies of Shapiro (1939) and Lasker (1946).

The Kurdish Jews surpass the Yemenite Jews more in transverse than in longitudinal measurements, suggesting – on the basis of the findings discussed above – that environmental factors may contribute more than genetic factors to the anthropometric differences.

Tanner (1966) has emphasized that difference in skeletal proportions between human populations are largely under genetic control, whereas variation within a genetically

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homogeneous population is essentially with respect to size. It is thus also relevant to inquire: are the morphological differences between the Kurdish and Yemenite Jews chiefly of size, or of shape? Are the Yemenite Jews simply smaller Kurdish Jews?

The figures in table 7 show that in both sexes small differences in skeletal proportions exist between the groups. The Kurdish Jews have broader wrists and hands in relation to arm length, and broader knees and ankles in relation to leg length, than the Yemenite Jews. These indices demonstrate the relatively greater bony thickness of the Kurdish Jews. The Kurdish Jews also have relatively longer arms than legs, and slightly broader chests. These differences between the two groups are small but consistent, and support the view that the Kurdish and Yemenite Jews differ in shape as well as in size.

TABLE 7. SKELETAL PROPORTIONS (%)

	male		female	
	Kurdish Jews	Yemenite Jews	Kurdish Jews	Yemenite Jews
wrist breadth/arm length	7.7	7.5	7.9	7.4
hand breadth/arm length	10.7	10.4	11.4	10.9
ankle breadth/leg length	7.5	7.3	7.5	7.0
knee breadth/leg length	9.3	9.2	9.6	8.8
foot length/leg length	25.3	25.1	24.9	24.8
arm length/leg length	76.8	76.7	76.7	76.3
chest breadth/chest depth	73.4	70.1	75.1	73.3

The shape difference between the groups extends to the head, the cephalic index being significantly greater in the Kurdish Jews in both sexes. This group thus lies in the brachycephalic range, with values typical of those found in central and eastern Europe (Barnicot 1964), while the means for the Yemenite Jews fall at the upper border of mesocephaly, and are more similar to those of African and some Mediterranean populations. The nasal index also differs between the two groups, nose form in the Yemenite Jews tending towards a more negroid shape.

The Kurdish Jews are heavier than the Yemenite Jews; the difference is particularly marked between the women in the two groups, although they hardly differ in height. This difference is partly accounted for by the larger skeletal size of the Kurdish Jews. The skinfold measurements in the women suggest that in them the difference in mass may also largely be due to fat. Amongst the men, however, skinfold thickness is greater at all sites in the Yemenite Jews (although the difference is only significant for the triceps skinfold). The mass difference here is thus unlikely to be due to fat. Greater muscularity in the Kurds may account for some of this mass difference: in lean body mass they exceed the Yemenites by a larger amount than the difference between the groups in body mass. This would also be consistent with the occupational difference between the males of the two groups, more Kurdish than Yemenite Jews being engaged in heavy physical work.

The energy intake of the Kurdish Jews was greater than that of the Yemenite Jews, although in both groups many of the subjects were obese in appearance. Compared to some recent standards of mass for height and age (Society of Actuaries 1959), there were some subjects, both male and female, in both groups who were 30% 'overweight'. Three times as many of the male Kurdish Jews were overweight as underweight, and among the female Kurdish Jews

this ratio was 8:1. Among the Yemenite Jews also there were more overweight than underweight subjects.

The anthropometric differences between the Kurdish and Yemenite Jews cannot be explained entirely on the basis of a proportionate difference in size. The two groups differ in their genetic constitution, and it seems probable that the Yemenite Jews, and, to a lesser extent, the Kurdish Jews, had been nutritionally deprived before entering Israel. Both groups now live under similar conditions, the only significant contrast being the larger energy intake of the Kurdish Jews. It is possible that the differences in skeletal proportions between the two groups could be due in part to their dissimilar genetic inheritance. Other anthropometric contrasts between the two groups could be attributed to malnutrition of the Yemenite Jews before their immigration to Israel, and to present differences in energy intake and occupation.

Skin colour

Levels of exposure to ultraviolet light have been similar for both Kurdish and Yemenite Jews since their immigration to Israel. Some other factor must therefore account for the significant difference in skin colour observed between the groups.

Meteorological data from the Yemen and from Kurdistan are not sufficiently detailed to specify what contrasts there may have been between the two groups in exposure to ultraviolet radiation before their immigration. In view of the difference in latitude between these regions (Kurdistan, 35 to 37° N; Yemen, 11 to 15° N), the Yemenite Jews could have had a considerably greater exposure than the Kurdish Jews. It is also possible that cloud cover over Kurdistan would be greater than over the Yemen. It would still appear doubtful, however, whether such climatic differences could provide sufficient selective pressure to account for the observed contrast in skin colour. The alternative is that the darker skin of the Yemenite Jews can be attributed to the inflow of African genes to this population.

The sex difference observed in these two groups is similar to that reported in other adult samples (Barnicot 1958; Weiner *et al.* 1964; Harrison *et al.* 1969). The decreasing variability from the short to the long wavelengths in both sexes (table 5) is characteristic of white, but not of negro populations (Barnicot 1958; Harrison & Owen 1964; Huizinga 1965, 1968), although the epidermal melanin content of both Israeli populations would appear to be substantially greater than that of Europeans.

The reflectance curves of both groups are similar to those of the other southwest Asian populations for whom measurements are available. The curve of the Yemenite Jews is very close to that of the Habbanite Jewish population from South Arabia (Hulse 1971). The Habbanites have a somewhat higher proportion of African blood group genes than the Yemenite Jews (Bonné *et al.* 1970; Godber *et al.* 1973), but resemble them in their origins and subsequent social history. The curve of the Kurdish Jews resembles those of the Chechen, Druze and Arab subjects (from the Caucasus, Syria and Jordan respectively), measured by Sunderland (1967).

The log and antilog transformations of the reflectance readings at 425 and 685 nm respectively, suggested by Harrison & Owen (1964), were arrived at empirically by consideration of the variances of European, West African and hybrid groups. On these scales, the environmental and heritable components of variation between these populations were found to be approximately independent, and the responsible genes to be additive in their effect. On these scales, also, the relative positions of different populations have been found to be more comparable at the two ends of the spectrum (Weiner *et al.* 1964).

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The sex and group differences in the Kurdish and Yemenite Jews were very similar on the transformed and untransformed scales. When the Israeli subjects were compared to other populations, however (figure 1), the transformations improved the comparability of the relations at the two wavelengths.

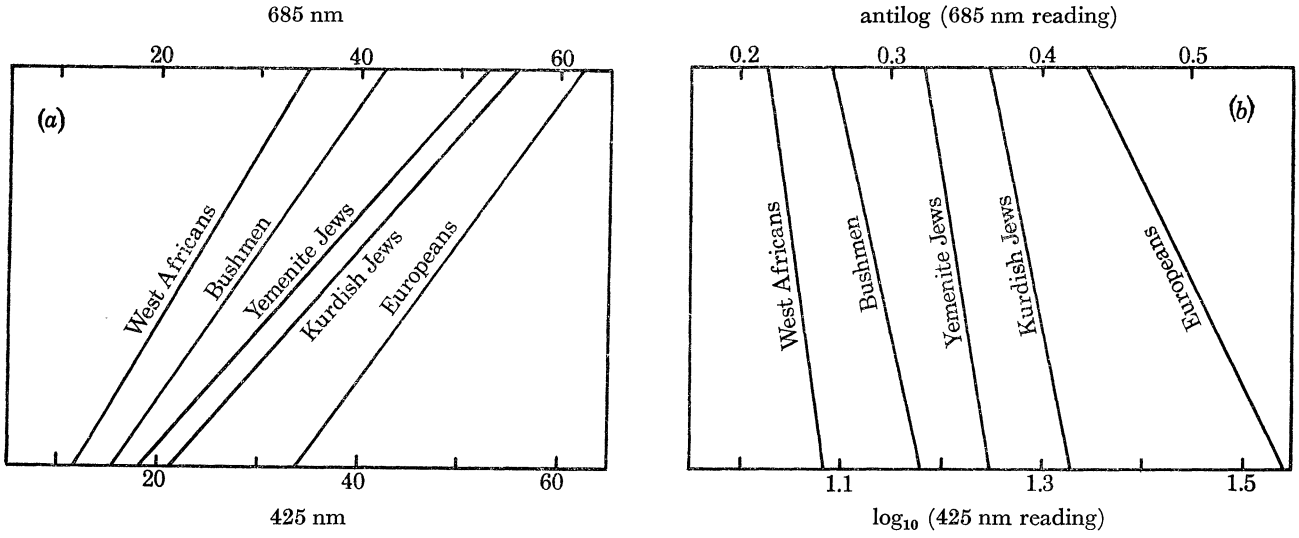

FIGURE 1. Skin colour reflectance in different male populations. (*a*) Untransformed values; (*b*) transformed values ($\log_{10}$ (425 nm); antilog (685 nm)).

From figure 1*b* it can be seen that the (male) Israeli groups were intermediate in skin colour between European and African populations. Both groups tended to be closer to the Europeans at the longest than at the shortest wavelength. Reflectance at the red end of the spectrum is least affected by variations in haemoglobin concentration, and is the best measure of epidermal melanin content (Jansen 1953; Barnicot 1958; Harrison & Owen 1964). It would therefore appear that the Israeli groups have a relatively low epidermal melanin content, but may be more similar to the Africans in the vascular or some other component of reflectance. Differential tanning between the Israelis and the other populations may also be responsible for some variation in these reflectance values (cf. Lee & Lasker 1959; Weiner *et al.* 1964; Harrison & Salzano 1966). Even when the measurement site is presumed to be unexposed to sunlight (e.g. the inside of the upper arm), different customs, such as the wearing of garments without sleeves, or using one arm to balance water pots on the head, may vitiate the assumption that these reflectance values are independent of the influence of ultraviolet radiation.

REFERENCES

Baker, P. T. & Weiner, J. S. 1966 *The biology of human adaptability*. Oxford: Clarendon Press.

Barnicot, N. A. 1958 Reflectometry of the skin in Southern Nigerians and in some mulattoes. *Hum. Biol.* **30**, 150–160.

Barnicot, N. A. 1964 In *Human biology* (ed. G. A. Harrison, J. S. Weiner, J. M. Tanner & N. A. Barnicot), p. 209. Oxford: Clarendon Press.

Bavly, S. 1973 Biological studies of Yemenite and Kurdish Jews in Israel and other groups in southwest Asia. V. Food intake of Yemenite and Kurdish Jews in Israel. *Phil. Trans. R. Soc. Lond.* B **266**, 121–126.

Ben-Zvi, I. 1958 *The exiled and the redeemed*. London: Valentine Mitchell.

Bonné, B., Ashbel, S., Modai, M., Godber, M. J., Mourant, A. E., Tills, D. & Woodhead, B. G. 1970 The Habbanite isolate. I. Genetic markers in the blood. *Hum. Hered.* **20**, 609–622.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Brunner, D. & Lobl, K. 1958 Serum cholesterol, electrophoretic lipid pattern, diet and coronary artery disease: a study in coronary patients and in healthy men of different origin and occupations in Israel. *Ann. intern. Med.* **49**, 732–750.
Clark, P. J. 1956 The heritability of certain anthropometric characters as ascertained from measurements of twins. *Am. J. hum. Genet.* **8**, 49–54.
Cohen, A. M., Bavly, S. & Poznansky, R. 1961 Change of diet of Yemenite Jews in relation to diabetes and ischaemic heart disease. *Lancet* ii, 1399–1401.
DuBois, D. & DuBois, E. 1916 A formula to estimate the approximate surface area if height and weight be known. *Arch. intern. Med.* **17**, 863–871.
Durnin, J. V. G. A. & Rahaman, M. M. 1967 The assessment of the amount of fat in the human body from measurements of skinfold thickness. *Br. J. Nutr.* **21**, 681–689.
Edholm, O. G. & Samueloff, S. 1973 Biological studies of Yemenite and Kurdish Jews in Israel and other groups in southwest Asia. I. Introduction, background and methods. *Phil. Trans. R. Soc. Lond.* B **266**, 85–95.
Field, H. 1939 Anthropology of Iran. *Field Mus. Nat. Hist. Anthrop. Ser.* **29**.
Field, H. 1951 The Anthropology of Iraq: the Northern Jazira. *Pap. Peabody Mus.* **46**, no. 1.
Field, H. 1952 The Anthropology of Iraq: Kurdistan. *Pap. Peabody Mus.* **46**, nos 2 and 3.
Field, H. 1953 Contributions to the Anthropology of the Caucasus. *Pap. Peabody Mus.* **48**, no. 1.
Field, H. 1956 An anthropological reconnaissance in the Near East, 1950. *Pap. Peabody Mus.* 48, no. 2.
Fischel, W. J. 1944 The Jews of Kurdistan a hundred years ago. *Jewish S. Stud.* **6**, 195–226.
Godber, M. J., Kopec, A. C., Mourant, A. E., Tills, D. & Lehmann, E. E. 1973 Biological studies of Yemenite and Kurdish Jews in Israel and other groups in southwest Asia. IX. The hereditary blood factors of the Yemenite and Kurdish Jews. *Phil. Trans. R. Soc. Lond.* B **266**, 169–184.
Goitein, S. D. 1947 *From the land of Sheba*. New York: Schocken Books.
Graham, G. G. 1968 The later growth of malnourished infants; effects of age, severity, and subsequent diet. In *Calorie deficiencies and protein deficiences* (ed. R. A. McCance and E. Widdowson). London: Churchill.
Harrison, G. A., Küchemann, C. F., Moore, M. A. S., Boyce, A. J., Baju, T., Mourant, A. E., Godber, M. J., Glasgow, B. G., Kopec, A. C., Tills, D. & Clegg, E. J. 1969 The effects of altitudinal variation in Ethiopian populations. *Phil. Trans. R. Soc. Lond.* B **256**, 147–182.
Harrison, G. A. & Owen, J. J. T. 1964 Studies on the inheritance of human skin colour. *Ann. hum. Genet.* **28**, 27–37.
Harrison, G. A. & Salzano, F. M. 1966 The skin colour of the Caingang and Guarani Indians of Brazil. *Hum. Biol.* **38**, 104–111.
Hiernaux, J. 1965 *La Croissance des ecoliers Rwandais*. Brussels: Acad. R. de Sci. d'Outre-mer.
Howells, W. W. 1966 Variability in family lines *vs.* population variability. *Ann. N.Y. Acad. Sci.* **143**, 624–631.
Huizinga, J. 1965 Reflectometry of the skin in Dogons. *Proc. K. ned. Akad. Wet.* C **68**, 289–296.
Huizinga, J. 1968 Human biological observations of some African populations of the thorn savanna belt. II. *Proc. K. ned. Akad. Wet.* C **71**, 373–390.
Hulse, F. S. 1971 Skin color among the Yemenite Jews of the isolate from Habban. *Proc. VIIIth Congr. anthrop. ethnol. Sci.* vol. 1, A **6**, 226–228.
Jansen, M. T. 1953 A reflection spectrophotometric study of ultraviolet erythema and pigmentation. *J. clin. Invest.* **32**, 1053–1060.
Lasker, G. W. 1946 Migration and physical differentiation: a comparison of immigrant with American-born Chinese. *Am. J. phys. Anthrop.* **4**, 273–300.
Lasker, G. W. 1954 Photoelectric measurement of skin color in a Mexican mestizo population. *Am. J. phys. Anthrop.* **12**, 115–122.
Lee, M. M. C. & Lasker, G. W. 1959 The sun-tanning potential of the human skin. *Hum. Biol.* **31**, 252–260.
Lippert, S. 1965 *Estimated body dimensions of the adult male Jewish population of Israel*. Haifa: Technion – Israel Institute of Technology, Dept of Aeronautical Engineering, TAE Report no. 40.
McCance, R. A. 1962 Food, growth, and time. *Lancet* ii, 621–626, 671–676.
McCance, R. A. 1968 The effect of calorie deficiencies and protein deficiencies on final weight and stature. In *Calorie deficiencies and protein deficiencies* (ed. R. A. McCance and E. Widdowson). London: Churchill.
Osborne, R. H. & de George, F. V. 1959 *Genetic basis of morphological variation*. Cambridge, Mass: Commonwealth Fund.
Roth, C. 1953 *A short history of the Jewish people*. London: East and West Library.
Seltzer, C. C. 1936 The racial characteristics of Syrians and Armenians. *Pap. Peabody Mus.* **13**, no. 3.
Seltzer, C. C. 1940 Contributions to the racial anthropology of the Near East. *Pap. Peabody Mus.* **16**, no. 2.
Semach, Y. 1910 *Une Mission de l'Alliance au Yemen*. Paris: Alliance Israelite Universelle.
Shanklin, W. M. 1935 The anthropology of the Rwala Beduins. *Jl R. anthrop. Inst.* **65**, 375–390.
Shapiro, H. L. 1939 *Migration and environment*. New York: Oxford University Press.
Society of Actuaries 1959 *Build and blood pressure study*, vol. 1. Chicago: Soc. of Am. & Am. Inst. Actuaries.
Sunderland, E. 1967 The skin colour of the people of Azraq, Eastern Jordan. *Hum. Biol.* **39**, 65–70.
Takkunen, J. 1964 Anthropometric, electrocardiographic, and blood pressure studies on adult male twins. *Suomal. Tiedeakat. Toim.* V. **107**, Suppl. 1–82.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Tanner, J. M. 1962 *Growth at adolescence*. Oxford: Blackwell Scientific Publications.
Tanner, J. M. 1966 Growth and physique in different populations of mankind. In *The biology of human adaptability* (ed. P. T. Baker and J. S. Weiner), pp. 45–66. Oxford: Clarendon Press.
Thomson, A. M. 1968 The later results in man of malnutrition in early life. In *Calorie deficiencies and protein deficiencies* (ed. R. A. McCance and E. Widdowson). London: Churchill.
Vandenberg, S. G. & Strandskov, H. H. 1964 A comparison of identical and fraternal twins on some anthropometric measures. *Hum. Biol.* **36**, 45–52.
Weiner, J. S. 1951 A spectrophotometer for measurement of skin colour. *Man* **51**, 152–153.
Weiner, J. S., Harrison, G. A., Singer, R., Harris, R. & Jopp, W. 1964 Skin colour in Southern Africa. *Hum. Biol.* **36**, 294–307.
Weiner, J. S. & Lourie, J. A. 1969 *Human biology: a guide to field methods*. Oxford: Blackwell Scientific Publications.
Weissenberg, S. 1909 Die Jemenitischen Juden. *Z. Ethnol.* **41**, 309–327.
Zaizov, R. & Laron, S. 1966 Body length and weight at birth and at one year of age in different communities in Israel. *Acta paediat., Stockh.* **55**, 524–528.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES