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# VII. The physical working capacity of Yemenite and Kurdish Jews in Israel

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The submaximal and maximal responses to exercise on a stationary bicycle ergometer were studied on 68 male and female Kurdish and Yemenite Jews. When the communities from Kurdistan and the Yemen were compared no significant differences were found between the men or the women, either in the summer or in the winter. There was no evidence for either an ethnic or seasonally determined variation in work capacity.

The maximum aerobic power ($V_{O_2, max}$) is now widely accepted as an international reference standard of physical working capacity (p.w.c.) in men. It is an effective measure of the combined capacities of the cardiovascular system to transport and the working muscles to utilize oxygen.

Unfortunately, in many situations, particularly in population studies, the direct estimation of $V_{O_2, max}$ is difficult. It is not an easy task to carry out a test requiring maximal physical effort on subjects not specially motivated for this. Furthermore, the extreme heart acceleration attained during the test is a potential hazard for untrained subjects. For these reasons, several authors have suggested that work capacity could be estimated with safety by measuring heart rate and oxygen consumption during progressive submaximal work loads.

In the present study we have compared the submaximal response to exercise and the maximum aerobic power of Kurdish and Yemenite Jews living in the southern arid zone of Israel (for details of location and occupation see Edholm & Samueloff 1973). They were of particular interest since, whilst being genetically dissimilar, they were living in similar environmental conditions and the results would not be confounded by short term environmentally determined effects on p.w.c. Furthermore, the tests were performed during the summer and repeated during the winter and we were therefore able to assess the seasonal variations in p.w.c. due to natural acclimatization to prevalent ambient conditions.

## Procedure and methods

During the summer, 32 Jewish subjects of Kurdish origin (20 males and 12 females) and 36 Jewish subjects of Yemenite origin (22 males and 14 females) were examined. During the winter, the tests were repeated on 21 Kurdish Jews (16 males and 5 females) and 25 Yemenite Jews (18 males and 7 females). The failure to repeat measurements on the females during the winter was mainly due to pregnancy; in the males due to refusal or absence.

Subjects were usually studied in pairs, 1 h after a light meal, in a temperature-controlled room at 23–24 °C. Before the work-capacity test, height and weight measurements were taken and subjects were requested to empty their bladders. Lean body mass was calculated from skinfold thickness measurements obtained using the Harpenden caliper after the method of Brozek, Mori & Keys (1958).

The experimental procedures and techniques were then explained to the subjects. They were allowed to become familiar with the respiratory valve, bicycle ergometer and pedalling at different work loads. Three disk electrodes (Devices Ltd) were fixed on the chest at standard e.c.g. lead positions and the e.c.g. record was checked, at rest and during pedalling. Calf and thigh volumes were measured by water displacement; subjects stood with their right leg in a water-bath with a graduated side tube. Measurements of displacement were at three levels, the malleolus, the tibial tuberosity and the maximum circumference of the thigh. Following these procedures the subject lay down on a bed and rested for 30 min. The exercise tests were carried out on the (Monark) bicycle ergometer which was repeatedly calibrated during the trial. The resistance of the ergometer was controlled mechanically. The subject timed his pedalling rate (50 rev/min) by listening to a metronome. The actual number of ergometer-wheel revolutions during the test was measured by means of an electric counter attached on the wheel and these counts were used in calculation of the work loads.

The work loads used in testing the males were 300, 600, 750 and 900 kp m $min^{-1}$ (3, 6, 7.5 and 9 kN m $min^{-1}$) or 900 and 1050 or 1200 kp m $min^{-1}$ (9, 10.5 or 12 kN m $min^{-1}$) depending on the heart rate and cooperation of the subjects. For the female subjects the applied work loads were 150, 300 and 450 kp m $min^{-1}$ (1.5, 3 and 4 kN m $min^{-1}$) and up. At each work load the exercise continued for 6 min at a pedal rate of 50 rev/min. During the last 2 min of each exercise period, heart rate was recorded (e.c.g.), respiratory rate counted (Tissot spirometer movements), and expired air collected.

Respiratory gas exchange was measured using an open circuit system. The subject breathed through a low resistance Otis McKerrow valve and expired air was collected during the last 2 min of work, through a short piece of wide (2.86 cm i.d.) smooth bore tubing, directly into a 300 l Tissot spirometer (Collins Ltd). The dead space of the gas collection system was washed out with subjects' expired air for 2 min before gas collection. The volume of the gas collected in the Tissot was recorded and samples for gas analysis were taken in small (3 l) vinyl plastic bags. An additional check of oxygen content was made on a Beckman model E2 oxygen analyser. Duplicates were required to agree within 0.05 vol %. Temperature and barometric pressure were recorded during gas collection and analysis, so the appropriate corrections of volume could be made. In a number of subjects maximum oxygen consumption was estimated directly. In these subjects work loads were raised to levels at which oxygen consumption and heart rate no longer increased. In all subjects regression lines of oxygen consumption ($V_{O_2}$), pulmonary ventilation ($V_e$) and heart rate ($f_h$) versus work loads were plotted and $V_{O_2}$ at work load 900 kp m $min^{-1}$ and $V_e$ and $f_h$ at 1.5 l/min oxygen intake were read out. 'Predicted' maximal oxygen consumption values were obtained by extrapolation of the oxygen consumption at 195 heart rate per min (Cotes *et al.* 1969).


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## Results

### *Physical characteristics of the subjects*

Values of mass, height and lean body mass estimations obtained during the summer experiments are given in table 1. The male Kurdish Jews were significantly taller ($P < 0.01$) than the Yemenite Jewish males; they were also heavier and had a larger body mass, but these differences were not significant. The Jewish Yemenite women were also lighter than the female Jewish Kurds, and had a smaller lean body mass, but the differences were not significant.

Calf and thigh volumes were measured in the majority of the participants in the winter trial and the data obtained are presented in table 1. The thigh volume of Jewish Yemenite men was significantly greater than that of Jewish Yemenite women ($P < 0.05$). A similar sex-determined trend was observed in the Kurdish Jews as well, although the difference was not statistically significant.

Table 1. Physical characteristics

| | Kurdish Jews | | | | | | Yemenite Jews | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | male | | | female | | | male | | | female | | |
| | *n* | mean | s.d. | *n* | mean | s.d. | *n* | mean | s.d. | *n* | mean | s.d. |
| mass/kg | 19 | 64.29 | 6.23 | 12 | 58.65 | 10.85 | 20 | 63.19 | 10.20 | 12 | 51.07 | 10.50 |
| height/cm | 19 | 168.90 | 6.75 | 12 | 153.90 | 3.89 | 20 | 163.20 | 5.05 | 12 | 152.60 | 6.79 |
| lean body mass/kg | 16 | 47.46 | 6.42 | 6 | 32.33 | 6.09 | 21 | 44.92 | 8.59 | 3 | 28.59 | 5.31 |
| calf volume $H_2O$ $cm^3$ | 14 | 2112 | 284 | 4 | 2224 | 518 | 14 | 2125 | 393 | 6 | 1696 | 424 |
| thigh volume $H_2O$ $cm^3$ | 14 | 4548 | 823 | 4 | 3696 | 174 | 14 | 4397 | 639 | 6 | 3466 | 862 |

Although the female Yemenite Jews had the smallest calf volume, the differences were not statistically significant compared with the Kurdish Jews, male and female, and the male Yemenite Jews who all had similar calf volumes. Table 2 shows that the $V_{O_2,\,max}$ of the Kurdish and Yemenite Jewish males was significantly higher ($P < 0.001$) than that of the females. This difference between the sexes of each community was reduced when $V_{O_2,\,max}$ was expressed in ml/kg and eliminated almost completely if related to lean body mass of the subjects.

Table 2. Maximum aerobic power (observed)

| | | Kurdish Jews | | | | Yemenite Jews | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | male ($n = 12$) | | female ($n = 2$) | | male ($n = 15$) | | female ($n = 4$) | |
| | | mean | s.d. | mean | s.d. | mean | s.d. | mean | s.d. |
| maximum aerobic power – observed $O_2$ consumption | l/min | 3.24 | 0.38 | 1.54 | 0.29 | 3.29 | 0.70 | 1.78 | 0.11 |
| | ml/kg body mass | 48.43 | 4.52 | 25.82 | 7.40 | 52.44 | 9.05 | 40.70 | 5.28 |
| | ml/cm height | 19.12 | 2.14 | 10.02 | 2.14 | 20.15 | 4.06 | 10.45 | 2.41 |
| | ml/kg lean body mass | 63.74 | 5.85 | — | — | 72.60 | 13.11 | 69.51 | 19.27 |

The maximum aerobic power of the Yemenite Jews was relatively higher in both sexes when compared with the Kurdish Jews, when expressed in ml/kg $min^{-1}$, although these differences were not statistically significant.

The predicted values of maximum aerobic power obtained by extrapolation of the oxygen intake to 195 beats/min on the $O_2$ consumption-cardiac frequency plot are given in table 3. Again, in both ethnic groups the absolute values for males were significantly higher than for females. These differences attenuate when the results are worked out per kilogram body mass and lean body mass. The predicted maximum aerobic power of the Yemenite Jews was relatively higher than that of Kurdish Jews, but the differences were not statistically significant.

TABLE 3. MAXIMUM AEROBIC POWER – PREDICTED AT HEART RATE 195/min

| | | Kurdish Jews | | | | Yemenite Jews | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | male ($n$ = 19) | | female ($n$ = 12) | | male ($n$ = 20) | | female ($n$ = 14) | |
| | | mean | s.d. | mean | s.d. | mean | s.d. | mean | s.d. |
| maximum aerobic power – predicted $O_2$ consumption | l/min | 2.89 | 0.46 | 1.63 | 0.33 | 2.98 | 0.50 | 1.77 | 0.43 |
| | ml/kg body mass | 44.45 | 7.05 | 28.96 | 8.28 | 46.91 | 5.27 | 35.40 | 7.73 |
| | ml/cm height | 16.72 | 2.67 | 10.51 | 1.98 | 18.23 | 2.81 | 11.65 | 2.60 |
| | ml/kg lean body mass | 60.13 | 10.20 | 54.38 | 10.70 | 66.48 | 7.07 | 62.40 | 15.63 |

The values of the observed $V_{O_2, max}$ are higher in both male groups and the Jewish Kurdish women than the predicted values. This suggests that in these population groups the use of a heart rate of 195/min may not be appropriate. The values of oxygen consumption at 900 kp m $min^{-1}$ (9 kN m $min^{-1}$) and of pulmonary ventilation and heart rate at 1.5 l/min oxygen consumption are summarized in table 4.

TABLE 4. SUBMAXIMAL RESPONSES TO EXERCISE

(Oxygen intake $V_{O_2, 900}$) at work load of 900 kp m $min^{-1}$ (9 kN m $min^{-1}$) ventilation ($V_{e, 1.5}$) and cardiac frequency ($f_{h, 1.5}$) at oxygen intake of 1.5 l/min.)

| | Kurdish Jews | | | | Yemenite Jews | | | |
|---|---|---|---|---|---|---|---|---|
| | male ($n$ = 19) | | female ($n$ = 12) | | male ($n$ = 20) | | female ($n$ = 12) | |
| | mean | s.d. | mean | s.d. | mean | s.d. | mean | s.d. |
| $V_{O_2, 900}$/l $min^{-1}$ | 2.38 | 0.23 | 2.22 | 0.29 | 2.36 | 0.22 | 2.29 | 0.73 |
| $V_{e, 1.5}$/l $min^{-1}$ | 42.01 | 6.62 | 54.54 | 5.23 | 40.86 | 4.18 | 49.95 | 6.76 |
| $f_{h, 1.5}$/beats min | 128 | 12.54 | 188 | 20.78 | 127 | 15.38 | 175 | 21.61 |

In both ethnic groups, males had a significantly higher $V_{O_2, max}$ in absolute terms than females ($P < 0.001$). Males accomplished the given level of submaximal work at a significantly lower pulmonary ventilation and cardiac activity, suggesting a higher efficiency in cardio-respiratory performance. Comparing both ethnic groups, the values obtained for predicted aerobic power were generally higher in the Yemenite Jews than the Kurdish Jews, but again the difference was not statistically significant.

A comparison of the submaximal responses to exercise and predicted $V_{O_2, max}$ obtained on the same subjects examined during the summer and winter are given in tables 5 and 6. It was only possible to repeat observations in the winter on a small number of women since many of the subjects studied in the summer were pregnant, so a valid statistical comparison of the results obtained in the women could not be made. However, as can be seen in tables 5 and 6, the results in the men were almost identical in the two seasons.


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TABLE 5. SEASONAL VARIATIONS IN MAXIMUM AEROBIC POWER PREDICTED AT HEART RATE 195/min

| | | | Kurdish Jews | | | | Yemenite Jews | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | male ($n$ = 13) | | female ($n$ = 2) | | male ($n$ = 18) | | female ($n$ = 6) | |
| | | | mean | s.d. | mean | s.d. | mean | s.d. | mean | s.d. |
| summer | maximum aerobic power – predicted $O_2$ consumption | l/min | 2.79 | 0.35 | 1.59 | 0.27 | 2.96 | 0.52 | 1.75 | 0.38 |
| | | ml/kg body mass | 44.75 | 5.01 | 31.29 | 13.61 | 46.78 | 5.23 | 35.16 | 2.96 |
| winter | | l/min | 2.97 | 0.25 | 1.87 | 0.04 | 2.98 | 0.49 | 1.87 | 0.35 |
| | | ml/kg body mass | 46.15 | 4.68 | 34.32 | 8.44 | 46.42 | 7.05 | 37.49 | 5.86 |

TABLE 6. SEASONAL VARIATIONS IN SUBMAXIMAL RESPONSES TO EXERCISE

(Oxygen intake ($V_{O_2, 900}$) at work load of 900 kp m min$^{-1}$ (9 kN m min$^{-1}$) ventilation ($V_{e, 1.5}$) and cardiac frequency ($f_{h, 1.5}$) at oxygen intake of 1.5 l/min.)

| | | Kurdish Jews | | | | Yemenite Jews | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | male ($n$ = 13) | | female ($n$ = 2) | | male ($n$ = 18) | | female ($n$ = 6) | |
| | | mean | s.d. | mean | s.d. | mean | s.d. | mean | s.d. |
| summer | $V_{O_2, 900}$/l min$^{-1}$ | 2.38 | 0.20 | 2.14 | 0.54 | 2.36 | 0.14 | 2.16 | 0.18 |
| | $V_{e, 1.5}$/l min$^{-1}$ | 41.13 | 5.65 | 53.67 | 0.45 | 41.11 | 3.80 | 50.66 | 5.90 |
| | $f_{h, 1.5}$/beats min$^{-1}$ | 128 | 11.03 | 191 | 19.10 | 126 | 15.50 | 177 | 23.04 |
| winter | $V_{O_2, 900}$/l min$^{-1}$ | 2.36 | 0.11 | 2.39 | 0.25 | 2.28 | 0.14 | 2.34 | 0.09 |
| | $V_{e, 1.5}$/l min$^{-1}$ | 43.47 | 4.70 | 50.47 | 3.36 | 40.16 | 4.29 | 46.91 | 7.46 |
| | $f_{h, 1.5}$/beats min$^{-1}$ | 128 | 11.21 | 170 | 7.10 | 125 | 14.61 | 169 | 23.57 |

## DISCUSSION

It is now well established that individual differences in maximum aerobic power do occur. However, few studies have been undertaken to investigate to what extent this difference is determined by environmental and to what extent by genetic factors. The difficulties inherent in such studies are obvious: large population groups have to be investigated and care must be taken to ensure that the groups *are* genetically dissimilar; furthermore, environmental factors such as nutrition and habitual activity which may contribute to $V_{O_2, max}$ have to be carefully standardized. In addition, the exercise test procedure must be similar for each population.

In the present study, these criteria seem to be adequately met. The Kurdish and Yemenite Jews are two genetically distinct ethnic groups now living under identical environmental conditions in Israel and have similar levels of habitual activity. They were tested by the same observers using a standard set of exercise equipment. Thus it should be possible to decide whether a true ethnic difference in working capacity exists or not.

The results obtained in this investigation suggest that there was little difference between the Kurdish and Yemenite Jews in their response to submaximal or maximal exercise and that there was no seasonal variation (tables 2 and 3).

In absolute terms, the observed and predicted $V_{O_2, max}$ was similar in the two groups. However, the Jewish Yemenite males were slightly lighter (table 1) and had less fat than the Jewish Kurdish males.


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The maximum aerobic power in relative terms per kilogram of body mass was higher in the male Yemenite Jews (52.4 ml $mg^{-1}$ $min^{-1}$ compared with 48.4 ml $kg^{-1}$ $min^{-1}$ in the Kurdish Jews) but this difference was not statistically significant (table 2). The same was true for the female groups. On average, the Jewish Kurdish women were some 7 kg heavier than the Jewish Yemenite women and the difference in working capacity was associated with a difference in the amount of adipose tissue. If $V_{O_2, max}$ is related to lean body mass the differences between males and females of both groups disappear (table 3). Thus, the apparent lower $V_{O_2, max}$ of the females was mainly a result of their smaller muscle mass. In addition, the predicted values of $V_{O_2, max}$ found in the two groups were closely similar to those reported for other ethnic groups and comparisons are shown in table 7.

TABLE 7. MAXIMUM OXYGEN CONSUMPTION IN DIFFERENT ETHNIC GROUPS (ml/kg)

| | | |
|---|---|---|
| | males | |
| Kurdish Jews | 44.5 | (present study) |
| Yemenite Jews | 46.9 | (present study) |
| Norwegians | 44.0 | (Hermansen & Andersen 1965) |
| South Africans | 43.5 | (Wyndham *et al.* 1966) |
| Italians | 45.0 | (di Prampero & Cerretelli 1969) |
| Canadians | 44.5 | (Shephard *et al.* 1968) |
| Americans | 43.5 | (Taylor *et al.* 1955) |
| Arctic Indians | 49.6 | (Andersen *et al.* 1960) |
| Bushmen | 47.9 | (Wyndham 1967) |
| Dorobo and Turkana (East Africa) | 46.0 | (di Prampero & Cerretelli 1969) |
| | females | |
| Kurdish Jews | 29.0 | (present study) |
| Yemenite Jews | 35.4 | (present study) |
| British | 34.5 | (Cotes *et al.* 1969) |
| Swedish | 35.9 | (Astrand 1960) |
| Pasuan | 31.0 | (Andersen 1967) |

However, it must be realized that all these studies, including the present investigation, have been undertaken on relatively small numbers of subjects and thus it would be inappropriate to draw definite conclusions regarding the importance or otherwise of genetic factors in determining the $V_{O_2, max}$ of a population group. Nevertheless, one can say from the results of this study that if true ethnic differences in $V_{O_2, max}$ do exist, they are likely to be small and certainly less than the wide inter-subject variation in maximum aerobic power which exists between members of the same ethnic group.

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